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THE EFFECT OF ENVIRONMENTAL FACTORS ON THE RESPIRATORY HEALTH OF SCHOOL CHILDREN IN HAMILTON

CURRENT REPORT #4

October 1, 1980

(Volume 4-1)

URBAN AIR ENVIRONMENT GROUP

McMASTER UNIVERSITY

TO

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THE EFFECT OF ENVIRONMENTAL FACTORS ON THE RESPIRATORY HEALTH OF SCHOOL CHILDREN IN HAMILTON

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October 1, 1980

(Volume 4-1)

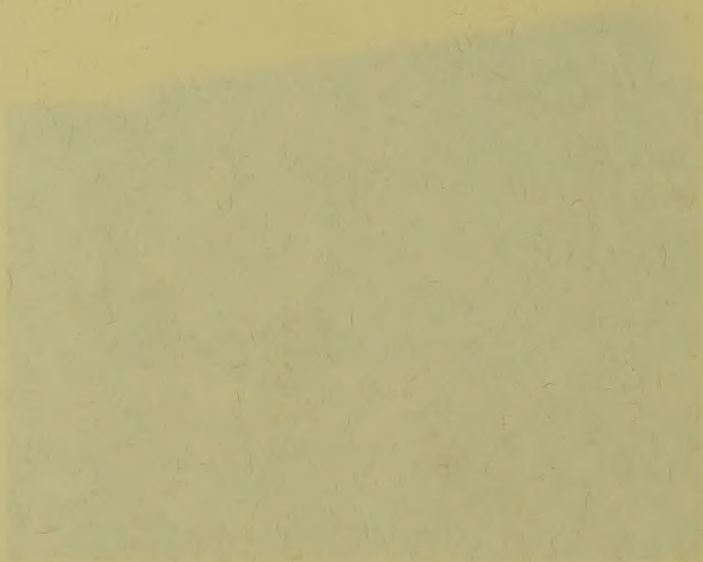
Submitted by:

A. T. Kerigan and L. D. Pengelly
Department of Medicine

C. H. Goldsmith
Department of Clinical Epidemiology and Biostatistics

B. K. Garside
Department of Engineering Physics

McMaster University
Hamilton, Ontario
Canada



This report is bound in two volumes, 4-1 and 4-2, due to its thickness. Page numbering is continuous throughout the two volumes, so that they may be read and referred to easily as one document. Volume 4-1 contains the Table of Contents for the entire report and Parts 1 through 8. Volume 4-2 contains Part 9 and the Appendices.

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PERSONNEL SUPPORTED BY PROJECT FUNDS

Stephen Toplack	Project Manager
Bill Furlong	Supervisor, Air Monitoring Studies
Wayne Spurgeon	Air Monitoring Technician
Ruth Hershler	Data Manager
Elizabeth Inman	Supervisor, Pulmonary Function Studies
Eva Corrigan	Pulmonary Function Technician
Danae Fraser	Pulmonary Function Technician
Chris Flasch	Assistant Pulmonary Function Technician
Deb Henry	Assistant Pulmonary Function Technician
Colleen Lafferty	Secretary
John Reid	Engineering Physicist
Alexander Quaglia	Research Assistant
Ian Rabenda	Technician
Fran Allen	Administrative Assistant

PART 1

INTRODUCTION

This report is intended to be read in conjunction with Current Report No. 1, March 1, 1979 (Report No. 1), Current Report No. 2, October 1, 1979 (Report No. 2), and Current Report No 3, April 1, 1980 (Report No. 3). This report follows roughly the same format as the three previous reports, and is intended to outline progress made since Report No. 3.

Part 7, Indoor Monitoring, presents our protocol for this section of the study. We hope to get this under way quite soon; a request for funding by contract will be submitted to Health and Welfare Canada shortly. Part 8, Preliminary Analysis of Year 1 Data, sets out some of the details of the labours of L.D. Pengelly while on sabbatical in Australia in 1979-80.

PART 2

QUESTIONNAIRE SURVEY

2.1 PROGRESS OF YEAR 2

Interviewing for Year 2 began in October, 1979. The completion rate in Year 2 for the first 22 schools is comparable to Year 1. Table 2-1 shows the response in each quadrant for Year 1 and Year 2 to date. It will be seen that the response rates in each quadrant are similar in both years.

TABLE 2-1

YEAR 1 AND YEAR 2 RESPONSE RATE IN EACH QUADRANT

	RESPONSE RATE (%)	
QUADRANT	YEAR 1	YEAR 2
East Lower	94.9	96.4
West Lower	94.2	94.9
East Mountain	98.0	97.7
West Mountain	96.3	98.7

2.2 RE-SURVEYING OF CHILDREN FROM YEAR 1:

Since a major feature of this study is the longitudinal study of children over a three year period, the ability of the study to hold onto the original Year 1 sample will be an important index of the success of the epidemiological survey. Figure 2-1 shows the restudy rate in Year 2 in each quadrant, expressed as the percentage of Year 1 subjects studied in Year 2.

2.3 RESPIRATORY SYMPTOMS PREVALENCE RATES BY AGE

Previous studies have consistently shown that the prevalence of respiratory symptoms decreases with increasing age over the age range of this study. Table 2-2 shows the rate for each symptom on the questionnaire by age. For questions 4 and 6, there was a significant ($p < 0.05$) decrease in prevalence with age. For questions 1, 2A and 7, there was a trend for prevalence to decrease, although it did not reach statistical significance. In no case did the prevalence consistently rise with age. We feel that these results from Year 1 are consistent with those of previous studies. This change with age also dictates that any comparison of prevalence rates between quadrants will require age correction of those rates, due to differences in age composition among quadrant populations (see Report No. 3).

TABLE 2-2

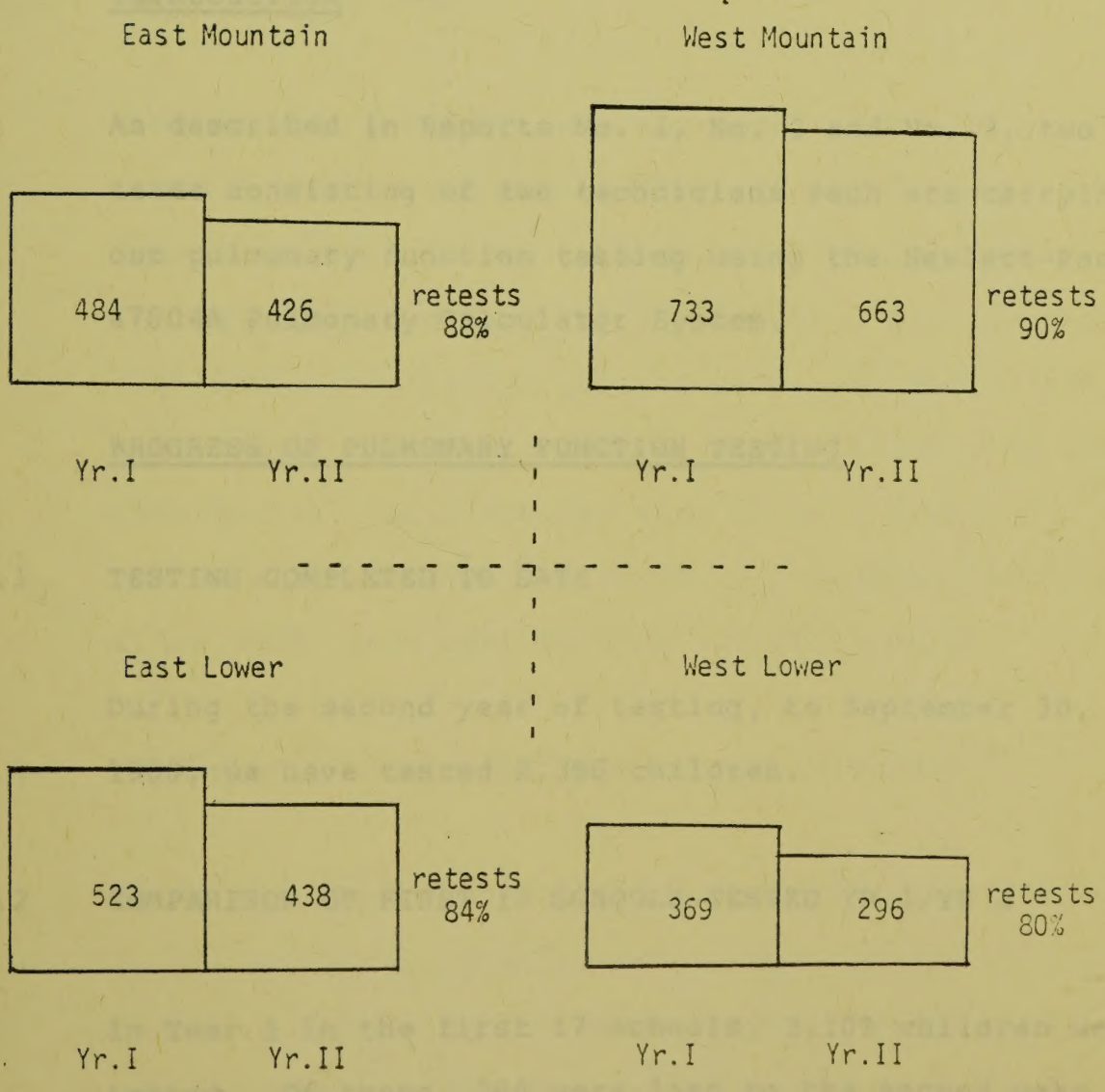
RESPIRATORY SYMPTOMS - PREVALENCE BY AGE

SYMPTOM BY QUESTIONNAIRE NUMBER	AGE 7	8	9	10	11
1. Cough in Morning	11.1	8.1	7.3	8.9	4.6
1A. Cough more than 3 months	5.6	5.1	5.0	5.3	4.5
2. Cough day or night	14.9	12.1	11.6	12.2	6.0
2A. Cough day or night more than 3 months	6.8	6.2	6.3	6.1	3.0
3. Wheezy	20.1	25.6	26.4	23.6	20.9
3A. Wheezy day or night	6.0	5.2	5.6	5.3	7.5
4. Asthma	6.4	4.5	4.0	2.6	3.0
5. Cold to Chest	41.6	38.6	37.1	36.8	44.8
6. Cold in last month	57.2	46.2	43.5	44.8	32.8
7. Cough/phlegm more than 3 weeks	17.8	15.5	14.5	12.2	11.9
8. Chest illness	8.2	8.6	7.1	8.3	9.0

Figure 2-1

COMPARISON OF FIRST 17 SCHOOLS TESTED - YEAR 1/YEAR 2

BY QUADRANT



PART 3

PULMONARY FUNCTION TESTING

3.0 INTRODUCTION

As described in Reports No. 1, No. 2 and No. 3, two teams consisting of two technicians each are carrying out pulmonary function testing using the Hewlett-Packard 47804A Pulmonary Calculator System.

3.1 PROGRESS OF PULMONARY FUNCTION TESTING

3.1.1 TESTING COMPLETED TO DATE

During the second year of testing, to September 30, 1980, we have tested 2,396 children.

3.1.2 COMPARISON OF FIRST 17 SCHOOLS TESTED YR 1/YR 2

In Year 1 in the first 17 schools, 2,109 children were tested. Of these, 286 were lost to the second year because they had moved out of the district. We were

able to test 1,823 children for the second time. This gives us a retest rate of 86%, matching our projection quite closely. We recruited 345 new children into the study, by picking up those in the grades being tested that met our age criteria. As a result, the final number for Year 2 for these schools was 103% of that for Year 1. (See Figure 3-1.)

3.1.3 EQUIPMENT FAILURES

Considerable problems were encountered from Sept. 1979 to June 1980 in the reliability of one of the Hewlett-Packard 47804A Pulmonary Calculator Systems. The equipment was (and is) covered by a service contract with Hewlett-Packard. Despite this, 191 hours were lost. This represents 20% of total testing time for this System. Both systems were given a full preventative maintenance check in September 1980, and since then, have been working satisfactorily.

3.1.4 EXTENSION OF STUDY INTO SENIOR PUBLIC SCHOOLS

As of September 1, 1980, the number of schools involved in the study increased greatly. This is due to a recent change in policy by the Hamilton Board of Education, regarding moving children from Elementary to Senior Public Schools at the end of Grade 5. Permission has

been obtained from the Board to follow children into these new schools, and the principals have all agreed to participate. Thus, the number of schools involved with the study has increased from 31 to 51.

3.1.5 SCHEDULING OF TESTING

Scheduling has become very complex, as children from one elementary school can, in some instances, move into several senior public schools; conversely, senior public schools can draw from several of our elementary schools. The number of moves in and out of schools will increase, and the length of time spent in any one school will decrease dramatically. From September 11 to November 2, 1979, 572 children were tested in 8 schools. There were just over 70 children per school, on average. Our projection for a similar time period in 1980, assuming that approximately the same number of children are to be tested, requires that we move into and out of 14 schools. There will be just over 40 children per school. Wherever possible, all children at one school will be tested at the same time. In most cases, however, this will be impossible if we are to ensure each children is tested at approximately the same time of year in Year II as in Year I.

3.1.6 PROTOCOL & CRITERIA

Procedures and criteria relevant to Pulmonary Function Testing are unchanged from those described in Report No. 2 of October 1979.

3.2 ADDITIONAL INFORMATION BEING OBTAINED SINCE LAST REPORT

3.2.1 SMOKING STATUS OF CHILDREN

From the beginning of the study, children were asked orally if they smoked. Almost without exception, they denied doing so. We felt we were not getting honest replies. In June of 1980 we designed a small questionnaire which the children completed under promise of absolute secrecy (see Appendix 3-1). To date, analysis of this data shows that we are getting much more information than by the old approach.

3.2.2 EVALUATION OF THE ACQUISITION AND VALIDITY OF THE NWs TEST

When the study was originally designed, it was felt important to include the Single Breath Nitrogen Washout Manoeuvre in the pulmonary function tests. This would provide closing volumes for each child; these are popularly supposed to give the earliest indication of

small airway closure.

From the beginning this test has been the most difficult to perform and to interpret.

For the first 4 schools tested in 1978-79, we obtained successful manoeuvres on only 49.8% of the children. With practice, this has steadily improved. At present, the success rate is 85%. This is satisfactory; but, to achieve this, we devote about 50% of the total testing time per child to this one manoeuvre. Each child is allowed up to 5 tries to achieve two acceptable results. At the beginning of the second year of testing, we decided to examine the success rate for each try, as it was possible that after a certain number of failures further effort was wasted. We coded each try as a success or failure, and analyzed the data for 706 children by age. We saw, as we expected, that success rates fell off after the first two tries. We also saw, again as we expected, that it was with the youngest children that we had the poorest results. The analysis well illustrated the enormous effort that was being devoted to acquiring the data: On these 709 children, we obtained two successful closing volumes on 523, and one successful closing volume on a further 115 children. To get this, we made 2,427 tries, making it an expensive test in terms of effort.

We have further problems in the quantification of results: The interpretation of the results requires a fairly high degree of subjective decision making, and the Hewlett-Packard Pulmonary Calculator System often prints numbers that do not accurately represent the true results. Our technicians must scrutinize and often recalculate the results for every Single Breath Nitrogen Washout test. In Year 1 we accepted only 30% of results unchanged, and recalculated the rest.

Finally, the reproducibility of the Closing Volume test has given us cause for concern. We do retests on a random sample of children to look at the reproducibility of all tests. We do a linear regression of the original test against the retest. On our last analysis for the Vital Capacity (VC) manoeuvre the correlation co-efficient was 0.96, whereas for the closing volume manoeuvre it was only 0.31. This analysis was presented at the annual meeting of the Canadian Society of Cardiovascular and Pulmonary Function Technologists, in Hamilton, in September, 1980 (see abstract, Appendix 3-2).

We, therefore, have had to consider the value of keeping this test in our protocol. This question has been under discussion for some time. Before a final decision is

reached, we plan to investigate the effect of adopting even stricter criteria with respect to flow rates on the reproducibility of the test. A pilot study is being organized in October to test approximately 12 children to see if they can perform this test at all, at these lower flows. If they can, we will then organize a further investigation, in which we will obtain many repeat measurements on approximately 20 children and examine reproducibility of the Closing Volume against the reproducibility of our other tests. If this is still unsatisfactory we will not continue with this test into Year 3.

3.3 CODING

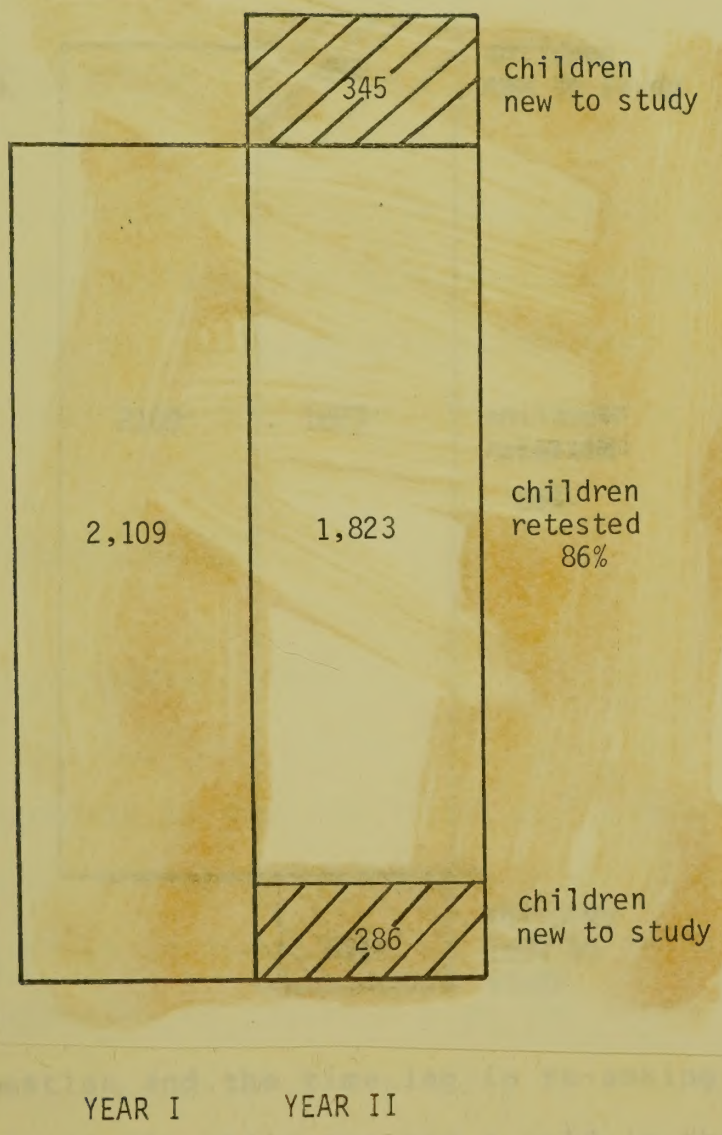
3.3.1 CODING PROCEDURES

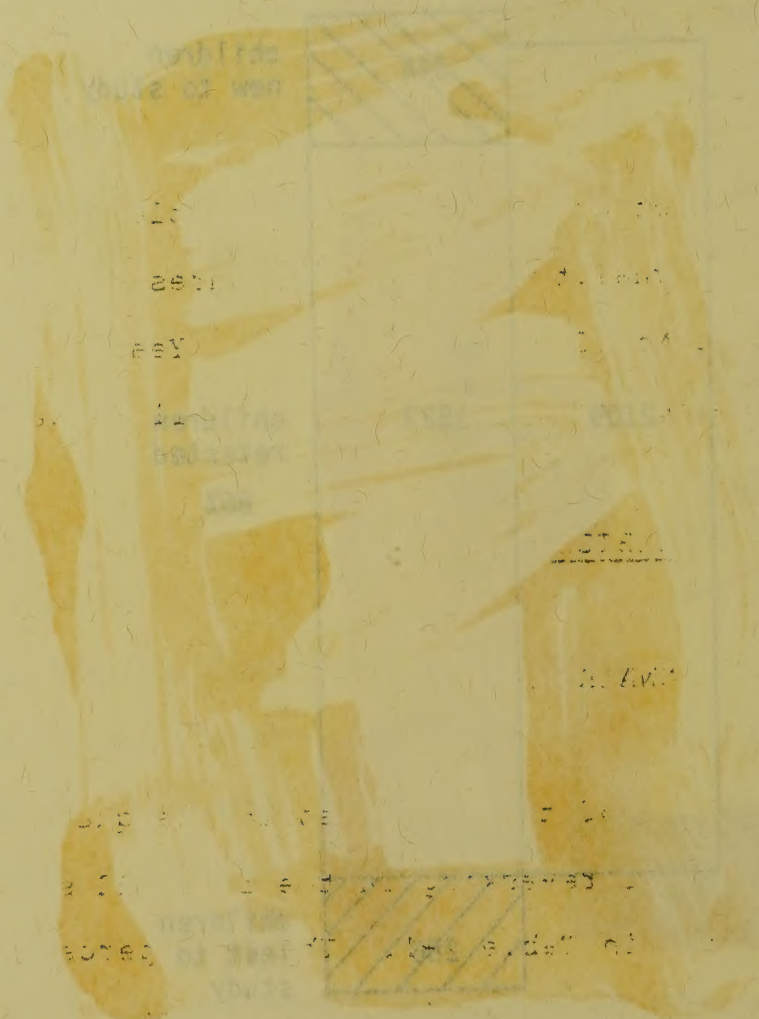
All coding is still being done by the two Assistant Pulmonary Function Technicians working in the schools. This is proving quite satisfactory, as they are able to fit the coding into their work-load comfortably. The quality of the coding, determined by routine quality controls as described in Report No. 3 is very good.

FIGURE 3-1

COMPARISON OF 1ST 17 SCHOOLS TESTED YRI/YRII

NUMBERS OF CHILDREN TESTED





PART 4

QUALITY CONTROL

4.0 INTRODUCTION

This section will update the tables and plots produced by the quality control procedures described in Current Report No. 3, which dealt with Year 1 data. Year 2 data collected through June, 1980 will be dealt with here.

4.1 REPRODUCIBILITY

4.1.1 QUESTIONNAIRE DATA

A summary of the responses to the questions randomly chosen for re-asking in the first 22 schools interviewed is shown in Table 4-1. The high percentage of mismatches to Question 6 is due to the nature of the question and the time lag in re-asking. The question asks if the child has had a cold in the last month.

4.1.2 LUNG FUNCTION DATA

As was outlined in Report No. 3, eight children from each school are selected for retesting. Table 4-2 is a summary of the paired t-tests produced using the repeat measurements from the first 17 schools tested in Year 2, while Figures 4-1 to 4-6 are scattergrams of these measurements.

4.1.3 CODING

The results of the coding verification done on the Year 2 data collected through June, 1980 is shown in Table 4-3.

4.2 KEYPUNCHING

All data keypunched is, as before, being verified by a second operator, keeping the possibility of keypunch errors below .005%.

4.3 STORAGE

Table 4-4 contains a summary of the percent of outliers found when passing the data to be stored through range-checking programs.

4.4 EDITING

We have continued to correct all errors found when data is quality controlled.

4.5 MONITORING FOR BIAS

4.5.1 QUESTIONNAIRE

As mentioned in the previous report, a profile of each interviewer is obtained as each pair of schools is completed, according to the response rates they obtain to preselected questions. Table 4-5 gives an example of such a profile.

4.5.2 PULMONARY FUNCTION TESTING

A summary of the percentage of missing values for the measurements of FVC, VC, RV, FRC, CV and N2DIFF for the first 17 schools tested in Year 2 is found in Table 4-6. Parallel line regression analysis has been used as described previously. To date, no systematic differences between the two teams of testers has appeared.

4.6 SUMMARY

The quality control routine we have established continues to be an effective means for the detection and correction of errors.

TABLE 4-1

QUESTIONNAIRE REPRODUCIBILITY (YEAR 2 - FIRST 22 SCHOOLS)

QUESTION CHECKED	NO. OF RESPONDENTS TELEPHONED	NO. OF MISMATCHED ANSWERS	RESPONDENT ID/ INTERVIEWER ID	NO. OF MISMATCHES NO. OF TIMES QUESTION REASKED (%)
2	8	1	02198/11	12.5
25	8	5	02015/11;02152/75 02175/70;33342/56 33342/56	62.5
1	20	0	-	0
17	8	3	05041/44 05054/44 06079/79	37.5
6	30	10	11024/48;12023/26 12047/11;12060/22 12072/22;12060/02 04064/52;17308/74 17322/71;18304/11	33
8	10	-	-	0
14	10	-	-	0
4	10	-	-	0
3	20	3	09187/10 09308/70 14151/56	15
25D	10	-	-	0
20	10	-	-	0
7	20	2	16023/12 21052/52	10
11	10	-	-	0
10	10	1	18304/11	10
5	10	2	20045/22	20
25B	10	-	20051/22	-
23	10	1	22043/56	10
TOTAL	214	28		13%

TABLE 4-2

REPRODUCIBILITY OF LUNG FUNCTION MEASUREMENTS
YEAR 2 (SCHOOLS 1 - 16, 18)

VARIABLE	NO. OF CASES	MEAN INITIAL	+/- SD REPEAT	T-VALUE	P
CV/VC	116	.12 +/-.08	.12 +/-.11	-.02	.982
FEV1	134	1.87 +/-.36	1.83 +/-.41	2.20	.029
FVC	134	2.32 +/-.47	2.28 +/-.52	2.26	.025
MEF50	134	2.43 +/-.62	2.33 +/-.67	2.60	.010
RV	132	.66 +/-.224	.66 +/-.22	.01	.994
MET	134	.59 +/-.17	.60 +/-.22	-1.50	.135

TABLE 4-3

CODER QUALITY CONTROL

	LUNG FUNCTION DATA (FOR 2 CODERS)		QUESTIONNAIRE DATA
Control based on	First 17 Schools Tested		First 22 Schools Tested
No. of Records (5% of all ages)	76	76	150
Coding Error Rate by Column	.48%	.99%	--
Coding Error Rate by Variable	.86%	1.6%	.11%
Keypunch Error Rate	0%	0%	0%

TABLE 4-4

RANGE CHECKS

	LUNG FUNCTION DATA (For 2 Cards)		QUESTIONNAIRE DATA
Checks based on	First 17 Schools Tested		First 22 Schools Interviewed
No. of Records Checked	2173	2173	2716
Coding Error Rate by Column	.04%	.08%	.00006%
Coding Error Rate by Variable	.05%	.09%	.008%
Variables of Range	3.6%	.64%	.001%
Keypunch Error Rate	0%	.00001%	.002%

TABLE 4-5

INTERVIEWER PROFILE FOR QUESTION 8 - HAS CHILD HAD A CHEST ILLNESS?

(Schools 19 - 22 Year 2)

INTERVIEWER I.D. NO.	QUESTION 8 YES (%)	NO	TOTAL
5	0(0.0)	14	14
12	3(21.4)	11	14
22	5(10.6)	42	44
26	0(0.0)	13	13
44	1(3.2)	30	31
49	3(9.4)	29	32
52	0(0.0)	16	16
56	1(2.7)	36	37
70	0(0.0)	13	13
71	3(10.7)	25	28
73	0(0.0)	31	31
74	3(9.1)	30	33
			309

CHI SQUARE = 16.3 11 df
P = .13

TABLE 4-6

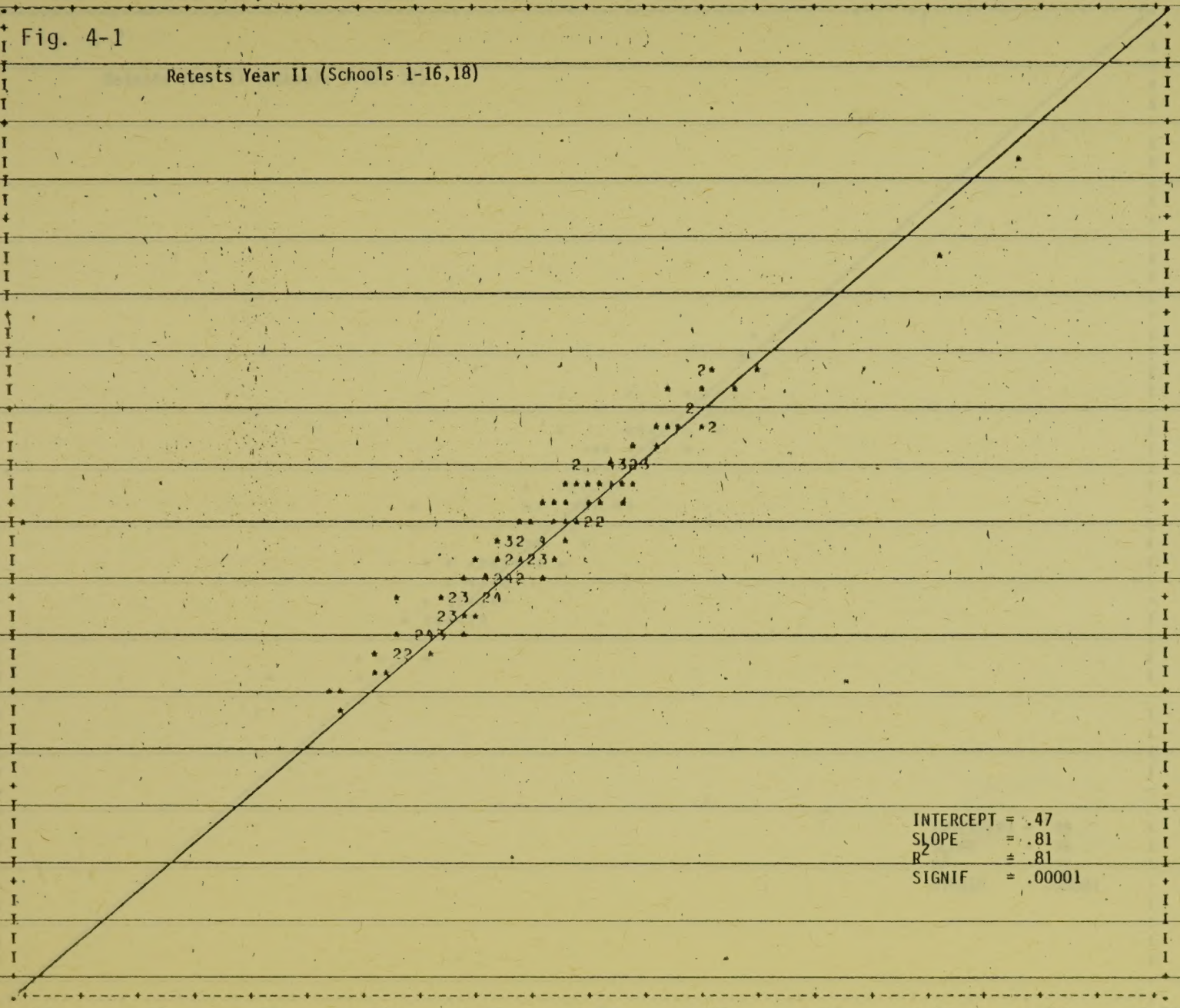
% MISSING VALUES FOR YEAR 2 (SCHOOLS 1-16, 17)

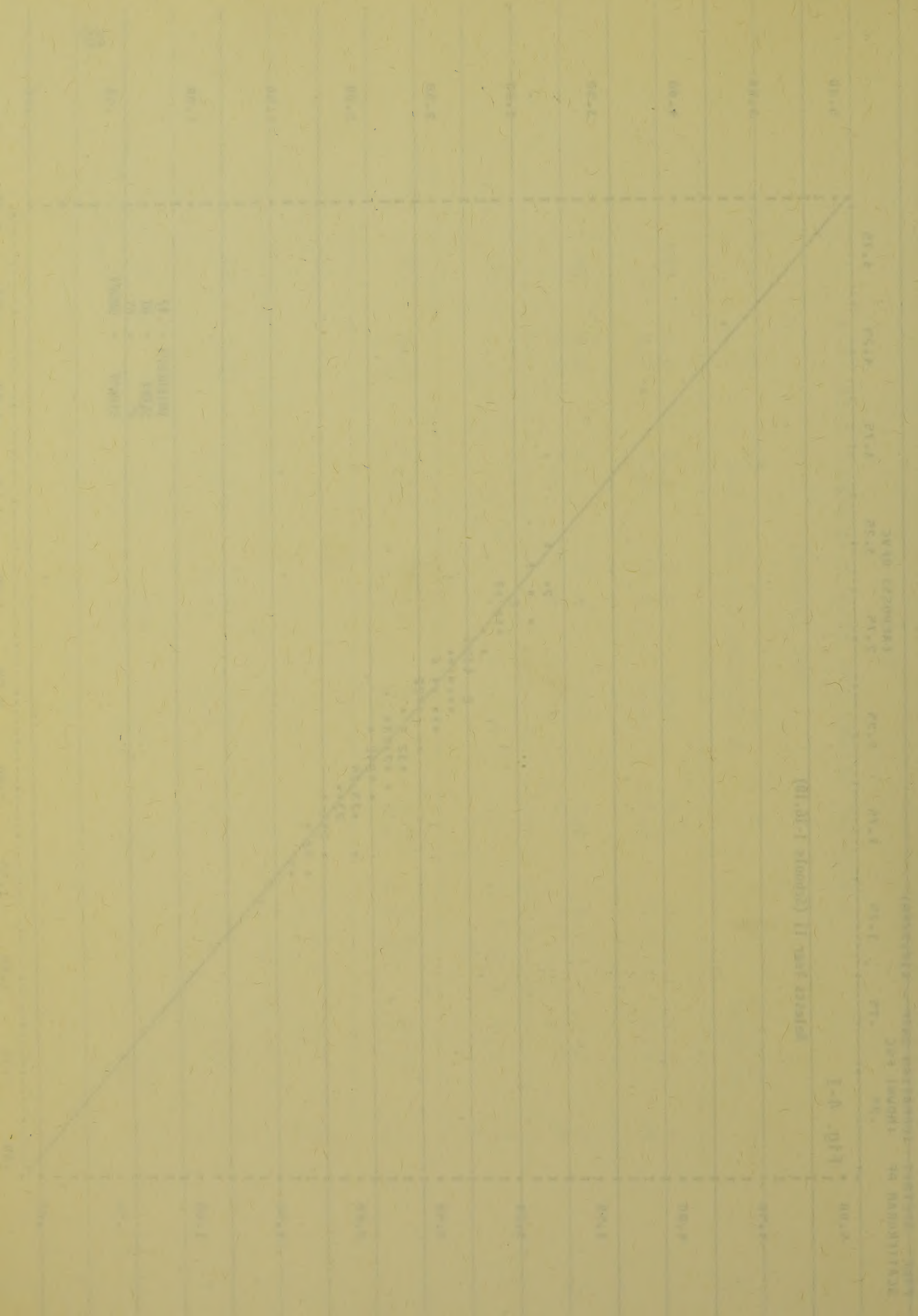
TEAM	TOTAL % MISSING	AGE (YEARS) 7	8	9	10	11	12	VARIABLE
		% MISSING FOR EACH AGE						
A	1.1	0.0	1.9	0.6	0.3	1.6	0.0	FVC
B	0.9	0.0	1.5	1.2	0.6	0.0	0.0	
A	1.1	0.0	1.9	0.9	0.3	2.4	0.0	VC
B	1.0	0.0	1.1	1.5	0.8	0.0	0.0	
A	1.4	--	--	--	--	--	--	RV
B	1.1	--	--	--	--	--	--	
A	18.0	33.0	27.3	16.8	13.7	13.7	15.8	CV
B	6.7	0.0	9.0	8.4	13.4	3.2	27.3	
A	0.8	0.0	1.4	--	--	--	--	FRC
B	1.0	0.0	--	--	--	--	--	
A	18.0	33.0	27.3	16.8	13.7	13.7	15.8	N2
B	6.7	0.0	9.0	8.4	13.4	3.2	27.3	
A	978	3	212	321	299	124	19	TOTAL NO. OF CHILDREN TESTED
B	1185	2	265	408	343	156	11	

FILE NRETST7 (CREATION DATE = 11/12/80)
SCATTERGRAM OF (DOWN) FVC (ACROSS) RFVC

Fig. 4-1

Retests Year II (Schools 1-16,18)

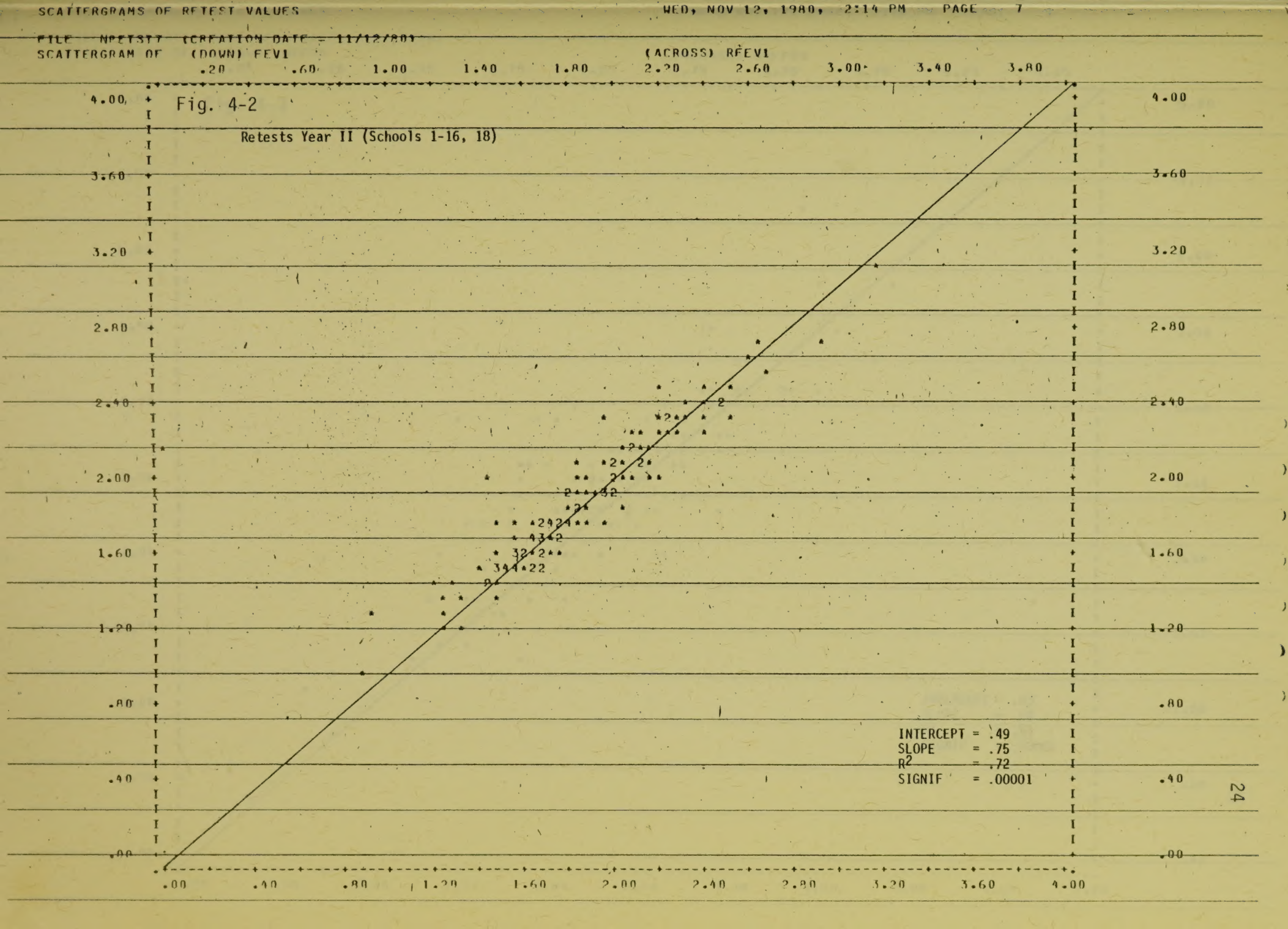




FILE NRETST7 (CREATION DATE = 11/12/80)
SCATTERGRAM OF (DOWN) FEV1 (ACROSS) RFEV1

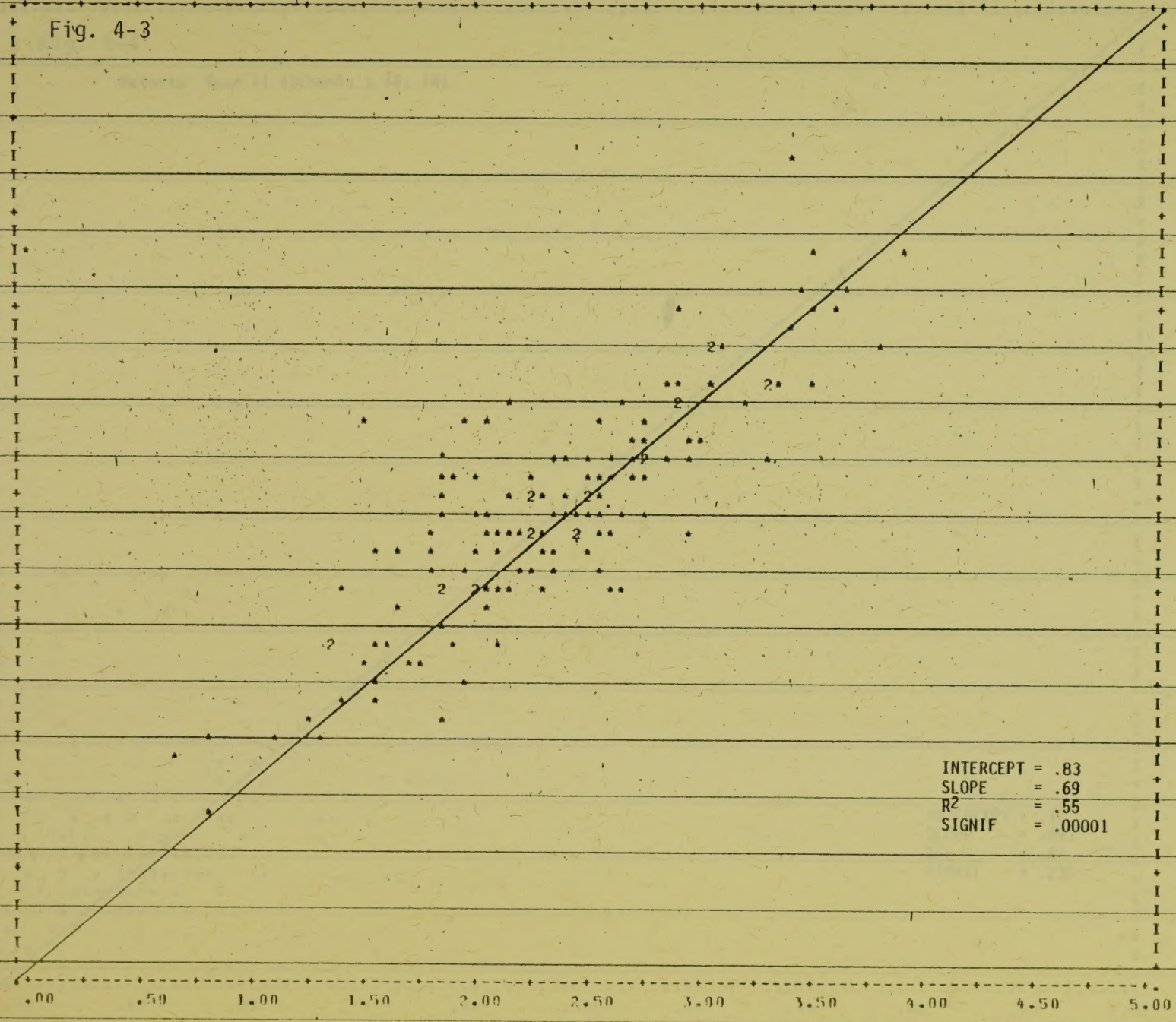
Fig. 4-2

Retests Year II (Schools 1-16, 18)



FILE N*FTST7 (CREATION DATE = 11/12/80)
SCATTERGRAM OF (DOWN) MEF50 (ACROSS) RMEF50

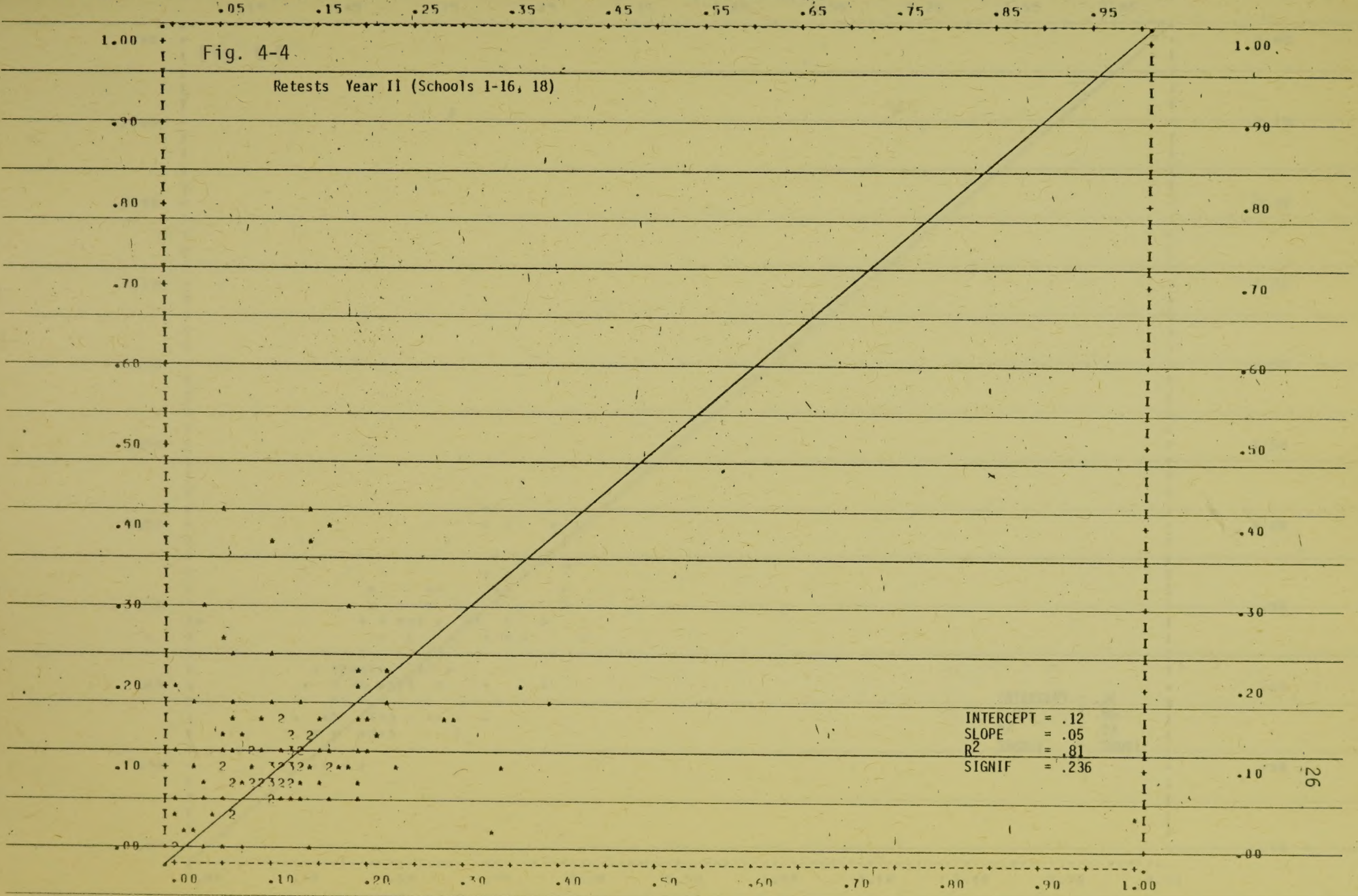
Fig. 4-3



FILE NRETST7 (CREATION DATE = 11/12/80)
SCATTERGRAM OF (DOWN) CVVC (ACROSS) RCVVC

Fig. 4-4

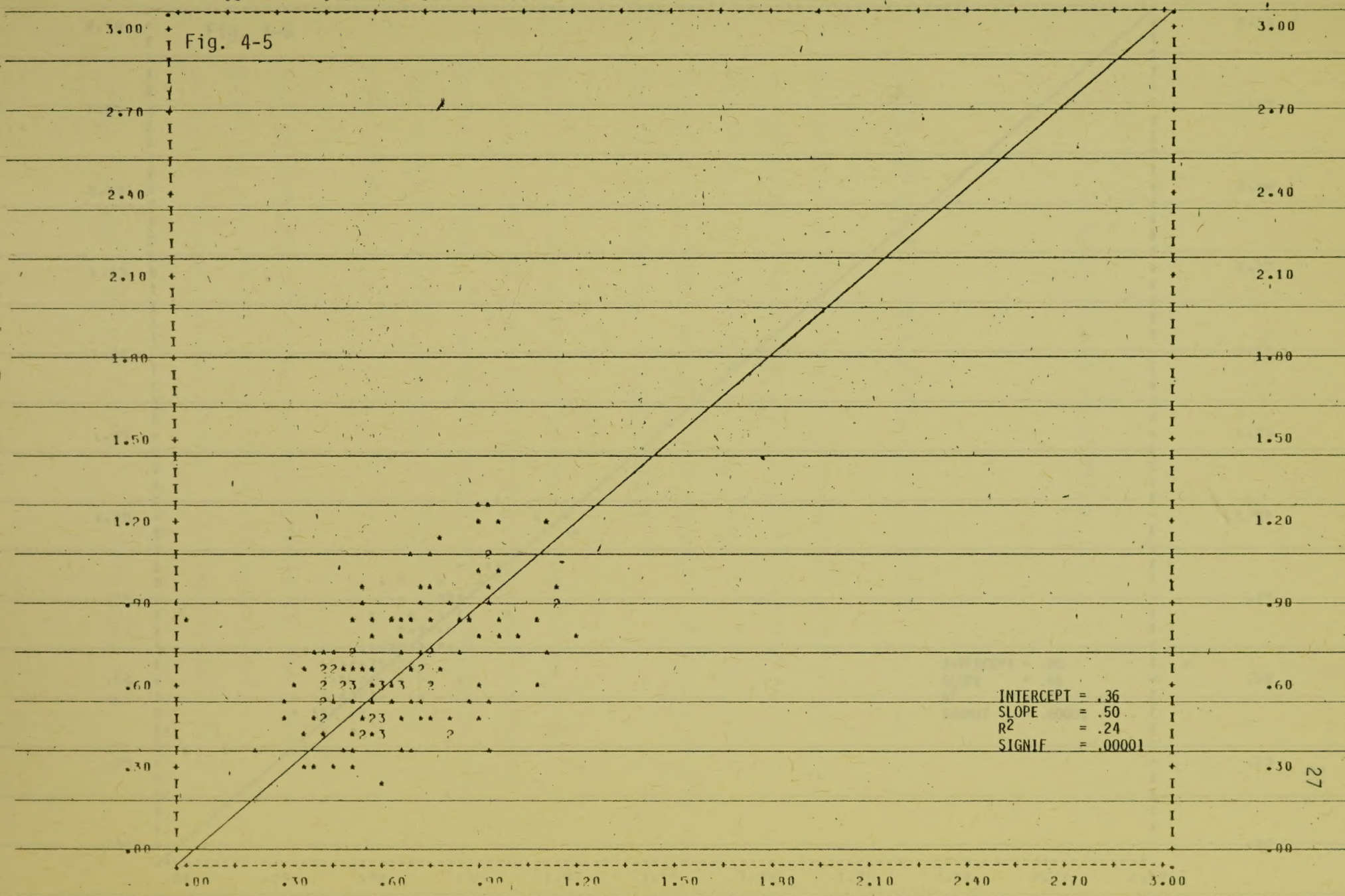
Retests Year II (Schools 1-16, 18)



FILE NRETST1 (CREATION DATE = 11/12/80)

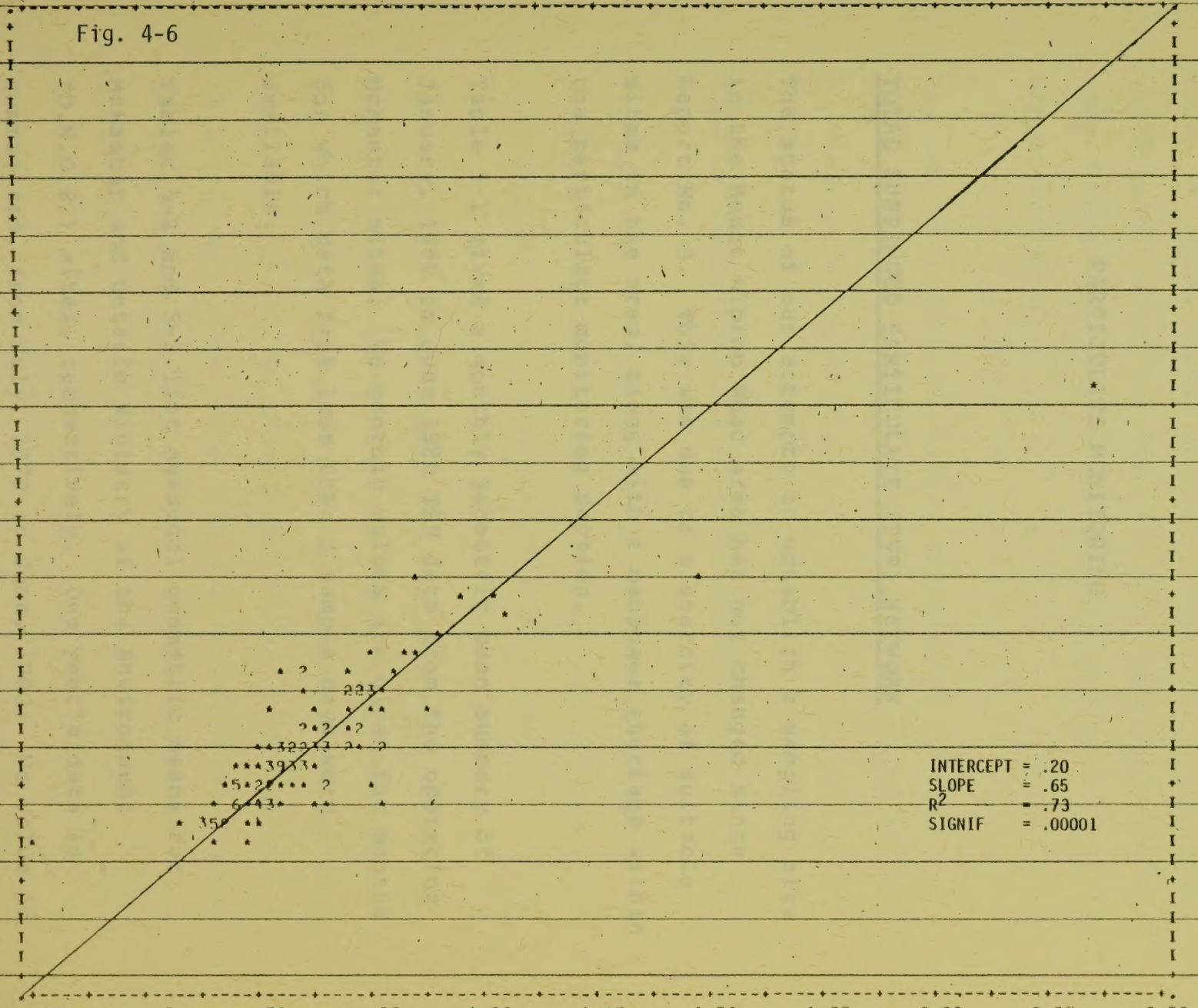
SCATTERGRAM OF (DOWN) RV (ACROSS) RRV

Fig. 4-5



FILE NMETST7 (CREATION DATE = 11/12/80)
SCATTERGRAM OF (DOWN) MET (ACROSS) RMET

Fig. 4-6



PART 5

PARTICULATE MONITORING

5.1 TOTAL SUSPENDED PARTICULATE (TSP) NETWORK

The status of our attempts to establish a sampling site in the Mount Albion Road area has not changed since Report No. 3. This was due to a scarcity of suitable sites in the area, along with a manpower shortage within the particulate monitoring section.

Table 5-1 gives a monthly geometric mean summary of January, 1980 to June 1980 TSP data from the operating McMaster sites. No monthly values are given for months for which data from less than 3 sample days were available.

Tables 5-2 and 5-3 list seasonal geometric means for McMaster and Ontario Ministry of the Environment (O.M.O.E.) sites, respectively. One year's data is summarized, from July, 1979 to June, 1980. No value is given for any site where data from less than 8 sample

days in a season are available.

Table 5-4 gives annual geometric means for both O.M.O.E. and McMaster sites for the year from July, 1979 to June, 1980. This data is also illustrated on Figure 5-1, a map of Hamilton.

All the above data is further represented by three-dimensional response surface plots, found in Part 9 (Figures 9-1 to 9-20).

5.2 PARTICLE SIZE DISTRIBUTION (PSD) NETWORK

PSD data has been collected on our network of seven samplers. Due to the volume of this data, it has not been included, but is available upon request.

Included in our new budget for the last nine months of the April, 1980 to March, 1981 fiscal year, were funds for two additional PSD samplers. One of these has been received and will be installed shortly at our Upper Ottawa Street site. This site was chosen on the basis of comparisons of TSP data from eligible mountain locations.

Table 5-5 lists mass median diameters (M.M.D.) (in microns) for our 7-sampler network (shown by site

numbers on Figure 5-2). These M.M.D.'s. are derived from cumulative percentages calculated on seasonal (the first four columns of M.M.D.'s.) and annual (the last column) bases. The time period covered is the year from July, 1979 to June, 1980, inclusive.

Further analysis is being carried out.

TABLE 5-1

TOTAL SUSPENDED PARTICULATE DATA

MONTHLY GEOMETRIC MEANS

JAN. - JUNE 1980

McMASTER SITES

(MICROGRAMS PER CUBIC METRE)

	JAN	FEB	MAR	APR	MAY	JUNE
Alberton	46	41	44	N/A	56	39
Mount Hope	46	43	46	35	54	50
San Diego	47	38	45	35	41	N/A
Upper Ottawa	40	42	35	29	48	38
Aberdeen	54	53	54	39	49	69
McElroy II	49	49	50	36	56	46
Whitney I	83	N/A	49	41	40	53
Red Hill Creek	43	44	40	30	49	50
Highview	39	54	48	40	55	49
Upper Wentworth	58	48	53	49	53	N/A
Cathedral Girls'	64	65	77	73	80	79
Westmount	47	41	48	31	39	42
Bishopsgate	47	45	40	35	60	63
Dundurn Castle	56	46	43	36	54	52
M.O.E.	76	64	63	51	76	68
Woodward	57	70	60	55	113	91

N/A = NOT AVAILABLE

TABLE 5-2

TOTAL SUSPENDED PARTICULATE DATA

SEASONAL GEOMETRIC MEANS

McMASTER SITES

JULY 1979 - JUNE 1980

(MICROGRAMS PER CUBIC METRE)

	JULY - SEPT 1979	OCT - DEC 1979	JAN - MAR 1980	APR - JUN 1980
Alberton	58	32	44	48
Mount Hope	65	35	45	45
San Diego	60	30	43	39
Upper Ottawa	56	30	40	38
Aberdeen	68	36	54	52
McElroy II	73	38	49	46
Whitney	69	42	56	45
Red Hill Creek	57	30	42	43
Highview	66	42	48	48
Upper Wentworth	68	41	53	54
Cathedral Girls'	94	62	70	77
Westmount	62	31	45	38
Bishopsgate	65	32	44	51
Dundurn Castle	57	38	48	45
M.O.E.	NIS	54	66	64
Woodward	NIS	NIS	62	82

NIS = NOT IN SERVICE

TABLE 5-3

TOTAL SUSPENDED PARTICULATE DATA

SEASONAL GEOMETRIC MEANS

O.M.O.E. SITES

JULY 1979 - JUNE 1980

(MICROGRAMS PER CUBIC METRE)

	JULY - SEPT 1979	OCT - DEC 1979	JAN - MAR 1980	APR - JUN 1980
Hughson/Hunter	90	56	74	86
City Hall	76	42	60	74
North Park	103	90	100	90
Kenilworth	76	48	101	77
Burlington/Leeds	136	104	142	146
Burlington/Wellington	87	58	78	83
Chatham/Frid	90	73	84	102
Barton/Sanford	99	78	90	113
Hughson St. N.	75	50	81	65
Mtn. Police Stn.	65	49	66	61
Cumberland Ave.	85	49	65	80
Barton/Nash	NIS	NIS	NIS	86

NIS = NOT IN SERVICE

TABLE 5-4

TOTAL SUSPENDED PARTICULATE DATA

ALL SITES

ANNUAL GEOMETRIC MEANS (A.G.M.)

JULY 1979 - JUNE 1980

(MICROGRAMS PER CUBIC METRE)

QUADRANT SITE NAME & NUMBER	McMASTER (Mc) O.M.O.E. (MOE) SITE	A.G.M. (ug/m^3)
West Mountain		
San Diego (103)	Mc	43
Westmount (114)	Mc	43
McElroy II (113)	Mc	50
Mountain Police Station (310/29085)	MOE	60
Upper Wentworth (111)	Mc	54
East Mountain		
Bishopsgate (115)	Mc	46
Highview (110)	Mc	51
Upper Ottawa (104)	Mc	40
West Lower City		
Whitney I (108)	Mc	52
Chatham/Frid (307/29017)	MOE	87
Dundurn Castle (116)	Mc	46
Aberdeen (106)	Mc	51

TABLE 5-4 (Cont'd.)

City Hall (302/29007)	MOE	61
Hughson/Hunter (301/29001)	MOE	75
Hughson St. N. (390/29067)	MOE	66
Burlington/Wellington (306/29012)	MOE	76
Cathedral Girl's (112)	Mc	77
<u>East Lower City</u>		
Barton/Sanford (306/29025)	MOE	94
Cumberland Ave. (311/29087)	MOE	69
Burlington/Leeds	MOE	130
	305/29011)	
Kenilworth N. (304/29009)	MOE	73
Red Hill Creek (109)	Mc	42
Woodward (118)	Mc	N/A
M.O.E. (117)	Mc	63
North Park (303/29008)	MOE	95
<u>Rural Mountain</u>		
Alberton (101)	Mc	44
Mount Hope (102)	Mc	46

TABLE 5-5

PARTICLE SIZE DISTRIBUTION DATA

ALL SITES

MASS MEDIAN DIAMETERS

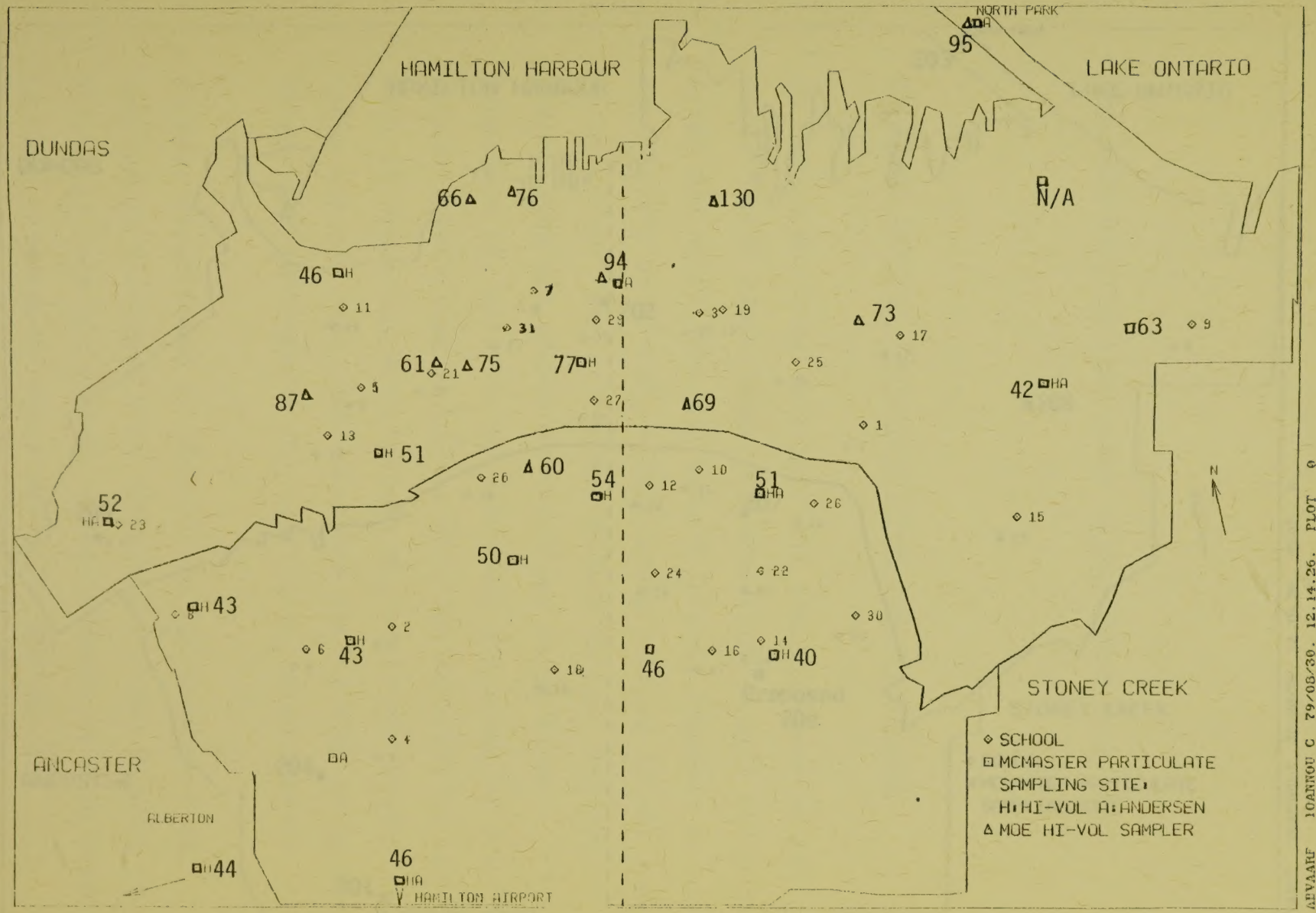
(MICRONS)

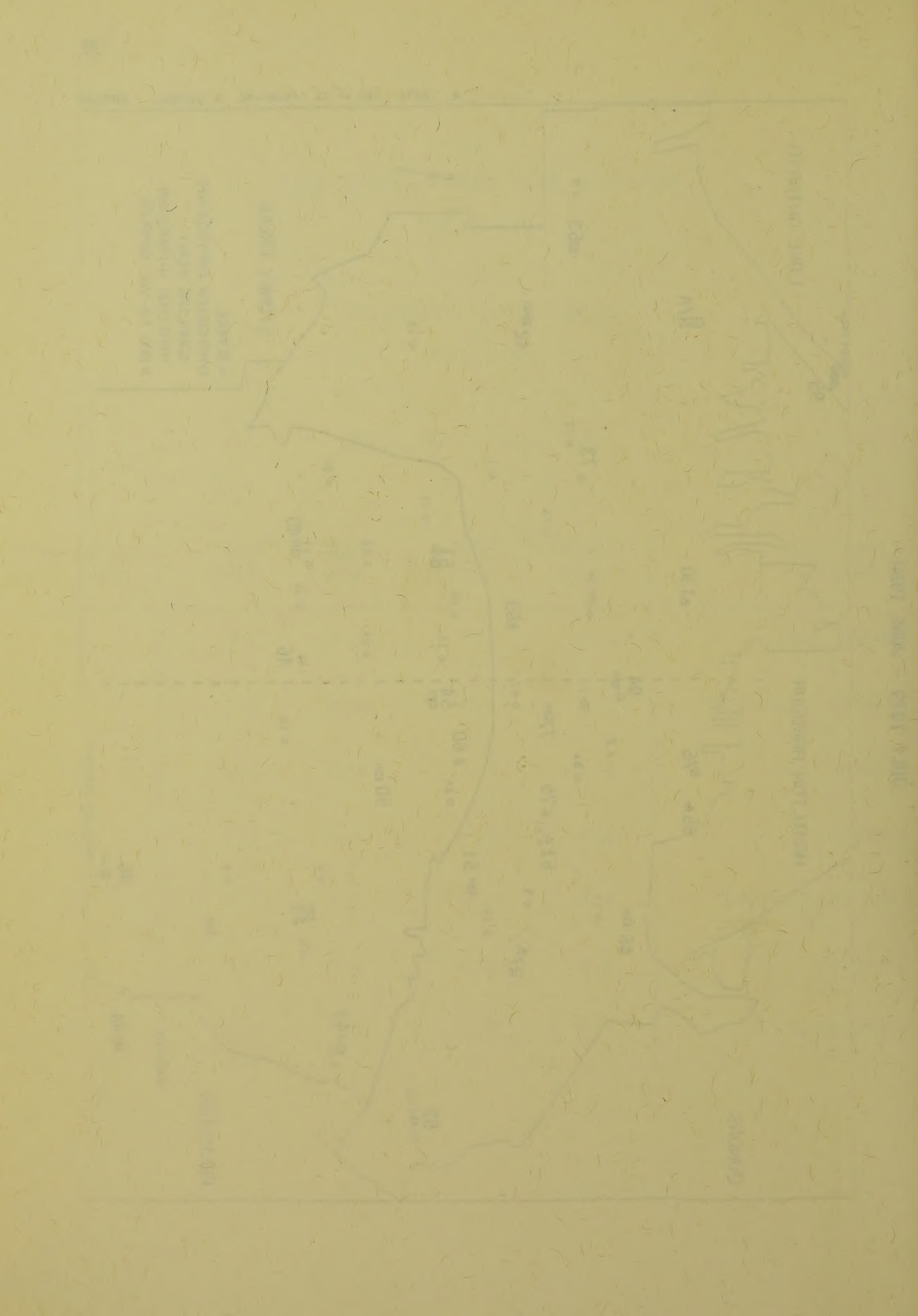
JULY 1979 - JUNE 1980

SITE NAME & NUMBER	1979 JULY - SEPT.	1979 OCT.- DEC.	1980 JAN.- MARCH	1980 APR.- JUNE	JULY 1979 TO JUNE 1980
MOUNT HOPE 201	2.9	3.7	4.5	3.6	3.6
BARTON & SANFORD 202	3.4	3.5	4.4	4.1	3.7
NORTH PARK 203	3.1	4.1	5.8	3.7	4.0
SENECA 204	2.8	2.4	3.2	3.1	2.8
RED HILL CREEK 205	2.8	2.6	2.9	2.9	2.8
WHITNEY 206	2.6	2.5	3.2	3.1	2.8
HIGHVIEW 207	3.0	3.0	3.7	3.6	3.3

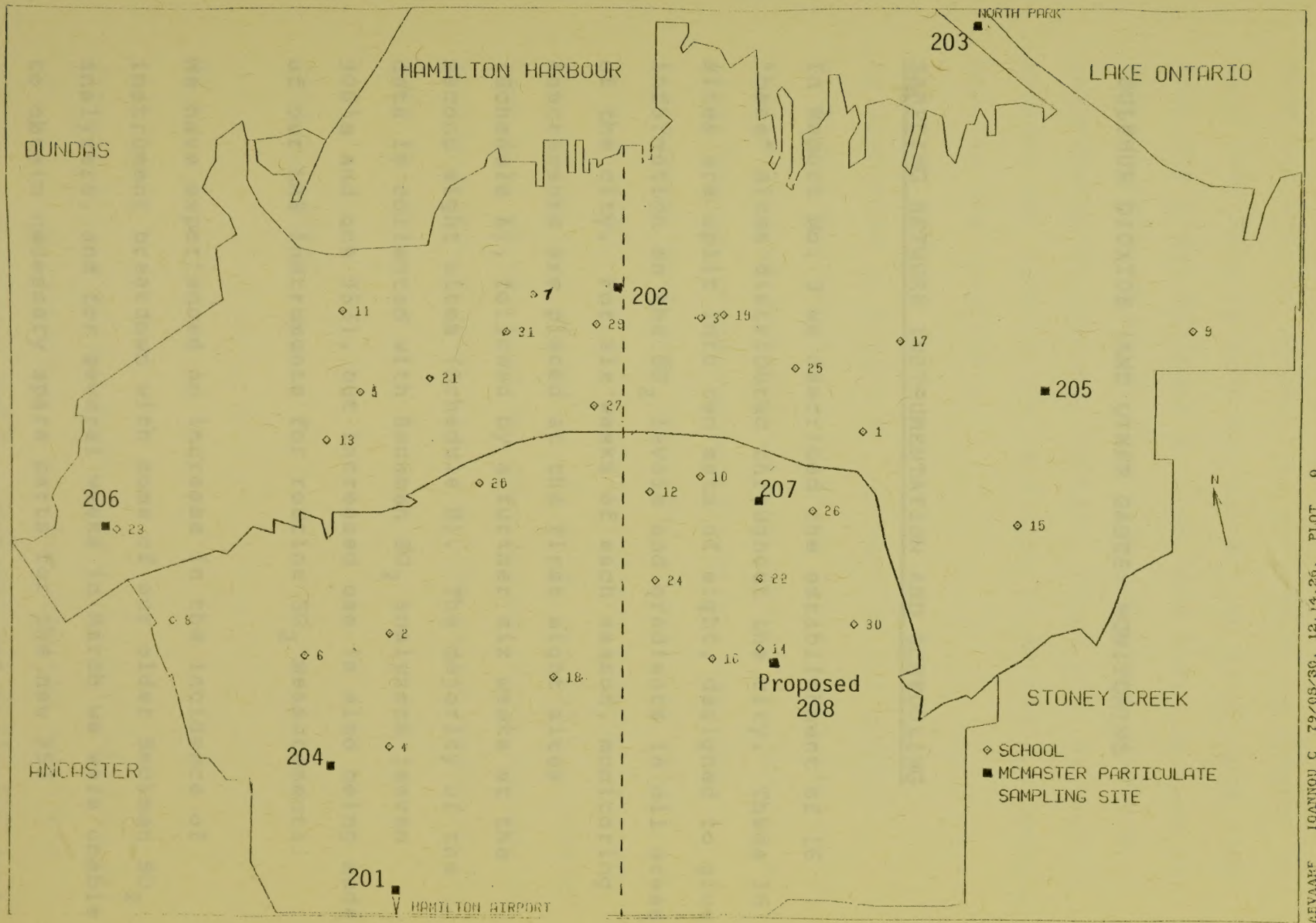
MAP OF HAMILTON SHOWING ANNUAL GEOMETRIC MEAN VALUES OF (in ug/m^3) FOR ALL SITES

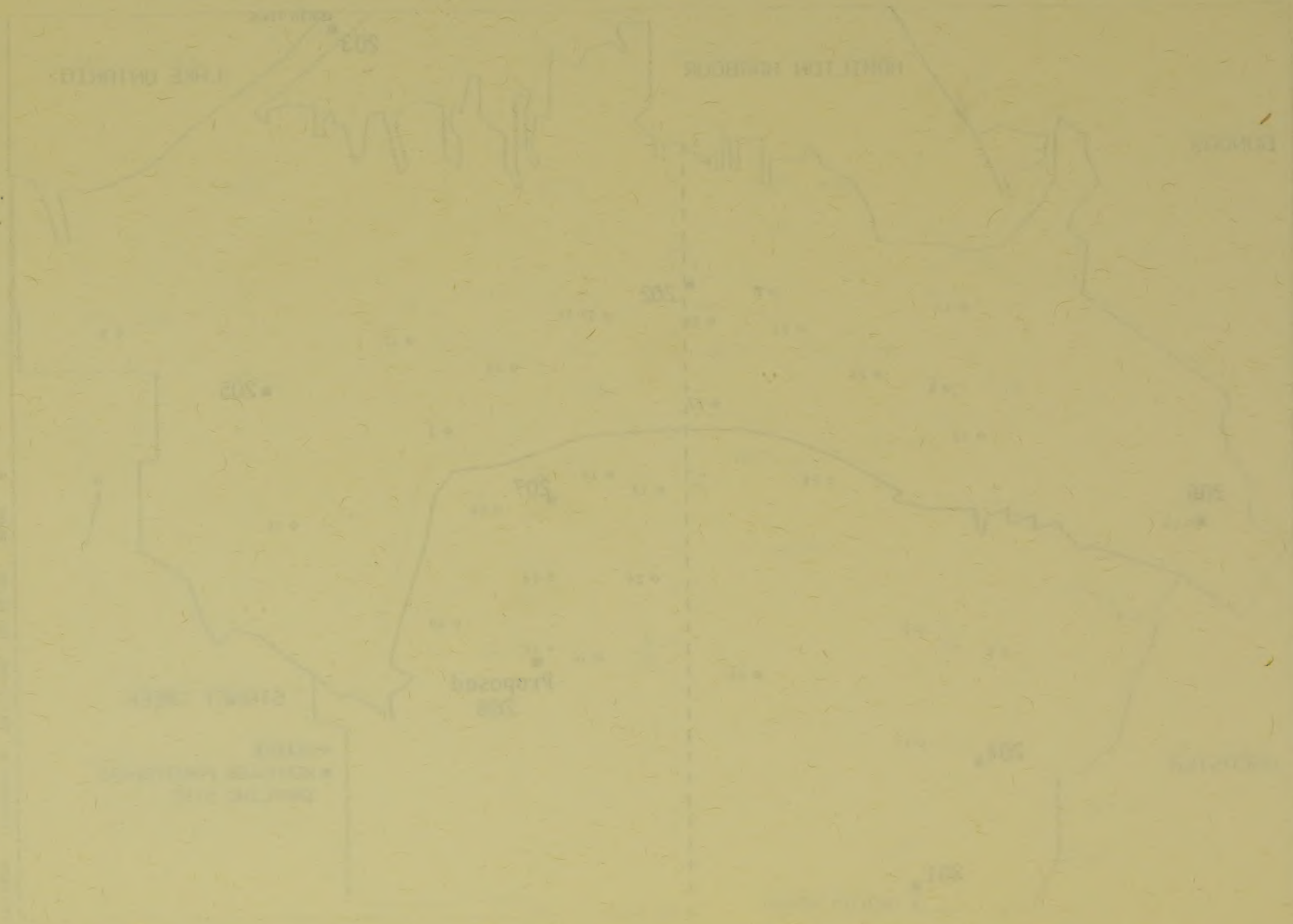
JULY 1979 - JUNE 1980





MAP OF HAMILTON SHOWING SITE NUMBERS OF PSD SITES





PART 6

SULPHUR DIOXIDE (AND OTHER GASES) MONITORING

6.1 SAMPLING NETWORK INSTRUMENTATION AND SCHEDULING

In Report No. 3 we described the establishment of 16 "base" sites distributed throughout the city. These 16 sites are split into two sets of eight, designed to give information on the SO_2 levels and gradients in all areas of the city. For six weeks of each season, monitoring instruments are placed at the first eight sites (Schedule A), followed by a further six weeks at the second eight sites (Schedule B). The majority of the data is collected with Beckman SO_2 analyzers (seven 906's and one 953), but increased use is also being made of our LAS instruments for routine SO_2 measurements.

We have experienced an increase in the incidence of instrument breakdown with some of our older Beckman SO_2 analyzers, and for several weeks in March we were unable to obtain necessary spare parts for the new 953 instrument. Despite these problems, and the unavoidable

loss of data which occurs when the instruments are moved from one site to another (or calibrated or checked for zero reading), we have maintained our total data loss from the eight Beckmans at less than 20%. We hope to improve this figure by obtaining additional Beckman instruments in the near future. These will be used to replace our older units, and also to maintain a back-up unit in the laboratory.

As described in Report No. 3, some of our present Beckman instruments will also be replaced by LAS units. (The displaced Beckmans will be used to monitor SO_2 at additional sites throughout the city). Two LAS instruments have been completed, a third is under construction, and a fourth laboratory version is used for calibration purposes. To date, the LAS instruments have been mainly used for spot checks of the Beckman SO_2 measurements, calibration, and some measurements of NO_2 (see below).

6.2 DATA COLLECTED

6.2.1 SO_2

Figures 6-1 and 6-2 display sample results obtained for the last two "seasons"; i.e., two complete rotations through Schedules A and B. Each number on the map

represents the arithmetic mean of the measured SO_2 concentrations in ppb, averaged over a period of 6 weeks. We also include the average SO_2 concentration recorded at the two MOE station's in the city. While this method of displaying the data takes no account of short term fluctuations or "pollution episodes", it does not indicate the average SO_2 distribution over the city for the last 6 months.

6.2.2 NO_2

In addition to the SO_2 data described above, we have also collected some preliminary data on NO_2 concentrations in the west end of the city. This data was taken with the second of our LAS instruments, which can be converted from SO_2 to NO_2 detection by simply switching between two lasers mounted in the instrument. A laboratory version of the NO_2 instrument has attained sensitivities of 0.1 ppb, and is described in detail in a recent publication (Appendix 6-1). Table 6-1 shows a sample of the data recorded with our field (LAS) instrument (sensitivity better than 1 ppb NO_2, readings taken every 4 minutes).

6.3 CALIBRATION OF BECKMAN SO_2 ANALYZERS

In this section, we outline the optical techniques used

to calibrate dilute SO_2 gas mixtures, which can then be used to calibrate Beckman SO_2 gas analyzers.

6.3.1 OPTICAL METHODS

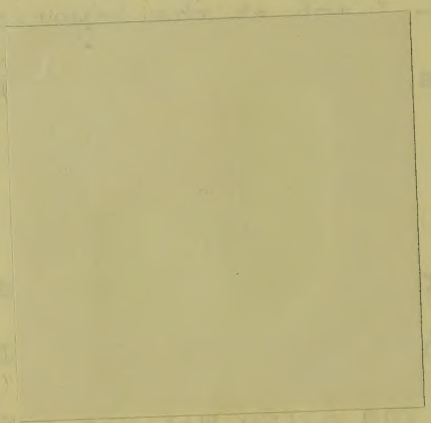
Our calibration techniques use the LAS instrument developed in recent years at McMaster. Full details of this instrumentation can be found in recent publications (Refs. 6-1 to 6-3). The next section is taken directly from one of these publications, and deals with linearity and calibration of the instrument for SO_2 detection.

6.3.1.1 Linearity and Calibration

An important property of any practical pollution monitoring instrument is that its response should be linear, and that it should be easily calibrated. The LAS is based on the measurement of optical absorption, and for the very small optical densities involved, Beer's law ensures linearity of response. Nevertheless, this linearity was checked under practical conditions. The diode laser was locked to an SO_2 absorption line. Then, calibrated SO_2 in N_2 mixtures were passed through the White cell. The results are shown in Table 6-2. The calibrated mixtures were prepared from an 820 ppb SO_2 in N_2 mixture supplied by Airco Industrial Gases. This standard mixture was then diluted with pure N_2

using a carefully-calibrated flowmeter system. Within experimental error, the LAS response was linear over the entire range from 20 to 820 ppb. The experimental error was small, being approximately 1 or 2% at the higher concentrations (limited by the resettability of the flowmeters) and +/- 1 ppb at the lower concentrations. These flowmeter results confirm the linearity of the LAS.

The absolute calibration clearly depends on the accuracy and stability of the concentration of SO_2 in the standard mixture. The Airco mixture was supplied in a specially coated aluminum cylinder designed to minimize concentration changes with time and temperature. Nevertheless, SO_2 mixtures in the ppb range are notoriously difficult to prepare and store, and an independent check on the calibration is in order. Fortunately, the LAS can be directly calibrated for mixtures in the ppb range using high SO_2 concentration mixtures, which do not suffer from the same preparation and storage problems. Over an interval of several months two cylinders of ~1000 parts per million SO_2 were obtained from Matheson Gas Products. These mixtures were passed, at the same pressure as in the multi-pass cell, through a 10 cm cell placed in front of the 5 m White cell. With the White cell set for a 160 m pathlength, the LAS response is equivalent to a mixture



of ~625 parts per billion flowing through the White cell. These results are also indicated in Fig. 6-3. The very good agreement obtained with mixtures differing in nominal concentration by 3 orders of magnitude, and from two different suppliers, confirms the absolute calibration of the LAS for the monitoring of SO_2.

We also make one further check on the high concentration mixtures. Using a suitable pathlength and pressure, we arrange that the ~1000 ppm mixtures absorb ~20% of the laser power on the strong SO_2 lines. We then make an accurate measurement of this absorption, and compare our measured value with the value predicted from the known optical constants of SO_2. Table 6-3 lists five recent measurements of the optical strength of the SO_2 band used in this work. Note that the total variation is less than 5%. Our optical measurement of concentration agrees with Matheson's estimate, which is based upon an entirely different technique (gravimetric analysis).

TABLE 6-3

Bandstrengths of the ν_3 band of SO_2 at ($1362\ cm^{-1}$) *

Value in $cm^{-2}\ atm^{-1}$	Year of Reference
802	1956
778	1957
778	1960
768	1970
780	1971

*Taken from "Molecular Spectroscopy: Modern Research" Vol. II, Ed. by K.W. Rao, p. 191.

We repeat our optical absorption measurements at regular intervals to ensure that the SO_2 concentration in the high concentration tanks does not change with time.

6.3.2 CALIBRATION OF BECKMAN GAS ANALYZERS

For this procedure, we use a tank of <250 ppb SO_2 in N_2 obtained from Airco. This tank is analyzed at Airco by gas chromatography, but we perform our own analysis as outlined above. Thus, the low concentration mixture is compared with a high concentration mixture using "optical length dilution", while the high concentration

mixture is checked by a direct measurement of optical linestrength. Generally, we find that the Airco analysis is initially accurate, but if our result differs from the Airco value, we use the SO_2 concentration as determined by our LAS techniques. (We found that the low concentration Airco mixtures become more and more dilute over a period of several months.)

The Beckman analyzers are then calibrated using the Airco mixture. The calibration is carried out on the most sensitive scale of the analyzer, i.e., with the instrument functioning as it does in the monitoring network. Hence our calibration gas must have a concentration of <250 ppb. The Beckman calibration is either carried out simultaneously with the optical calibration in the laboratory, or the gas tank is taken to the actual monitoring site for a field calibration. In the latter case, the Airco mixture undergoes an optical calibration in the laboratory both before and after its use in the field. This ensures that no changes in gas composition occur during the calibration period.

Some typical results of a recent calibration run are given in Table 6-2.

We normally calibrate our Beckman analyzers in this fashion at least once per rotation, and are hence able to correct the monitoring data for any systematic variations in instrument response.

TABLE 6-1

TYPICAL NO_2 DATA

JULY 10TH, 1980		JULY 11TH, 1980	
TIME	NO_2 ppb	TIME	NO_2 ppb
1000	37	0100	18
1100	29	0200	13
1200	20	0300	10
1300	21	0400	8
1400	22	0500	7
1500	26	0600	6
1600	23	0700	-
1700	26	0800	-
1800	21	0900	CALIBRATE
1900	20	1000	-
2000	20	1100	20
2100	24	1200	15
2200	32	1300	17
2300	21	1400	16
		1500	20
		1600	21
		1700	20
		1800	18
		1900	23

NO_2 concentrations are measured with the LAS in ppb, and are given as hourly averages. Measurements made on McMaster University Campus.

TABLE 6-2

A nominal 230 ppb SO_2/N_2 mixtures is analyzed With LAS and Beckman instruments.

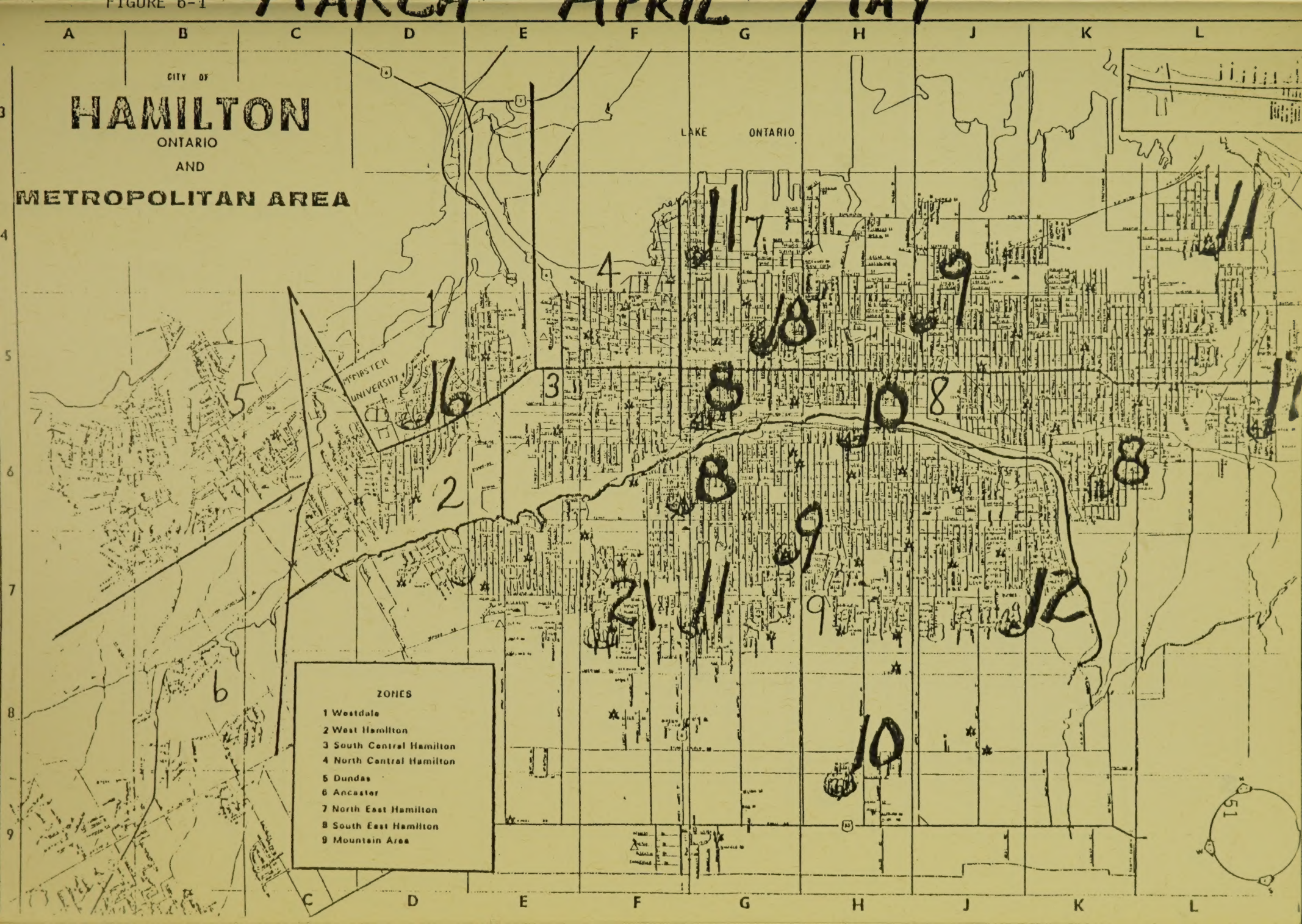
Instrument and Technique	Reading in ppb
Airco, Gas Chromatography	230*
LAS, Comparison with 1123 ppm mixture	163
LAS, Direct optical linestrength	160
Beckman 906 Analyzers (7 Instruments)	167
	150
	160
	160
	158
	160
	160

*The Airco calibration was made several months previous to the present measurements, and some change in concentration has occurred.

FIGURE 6-1

AVERAGE SO_2 CONCENTRATIONS IN ppb IN THE CITY OF HAMILTON FOR PERIOD MARCH - MAY 1980. EACH NUMBER REPRESENTS A SIX WEEK AVERAGE

FIGURE 6-1


CITY OF
HAMILTON
ONTARIO
AND
METROPOLITAN AREA
LAKE ONTARIO
MCMASTER UNIVERSITY
ZONES
1 Westdale
2 West Hamilton
3 South Central Hamilton
4 North Central Hamilton
5 Dundas
6 Ancaster
7 North East Hamilton
8 South East Hamilton
9 Mountain Area
A
B
C
D
E
F
G
H
J
K
L

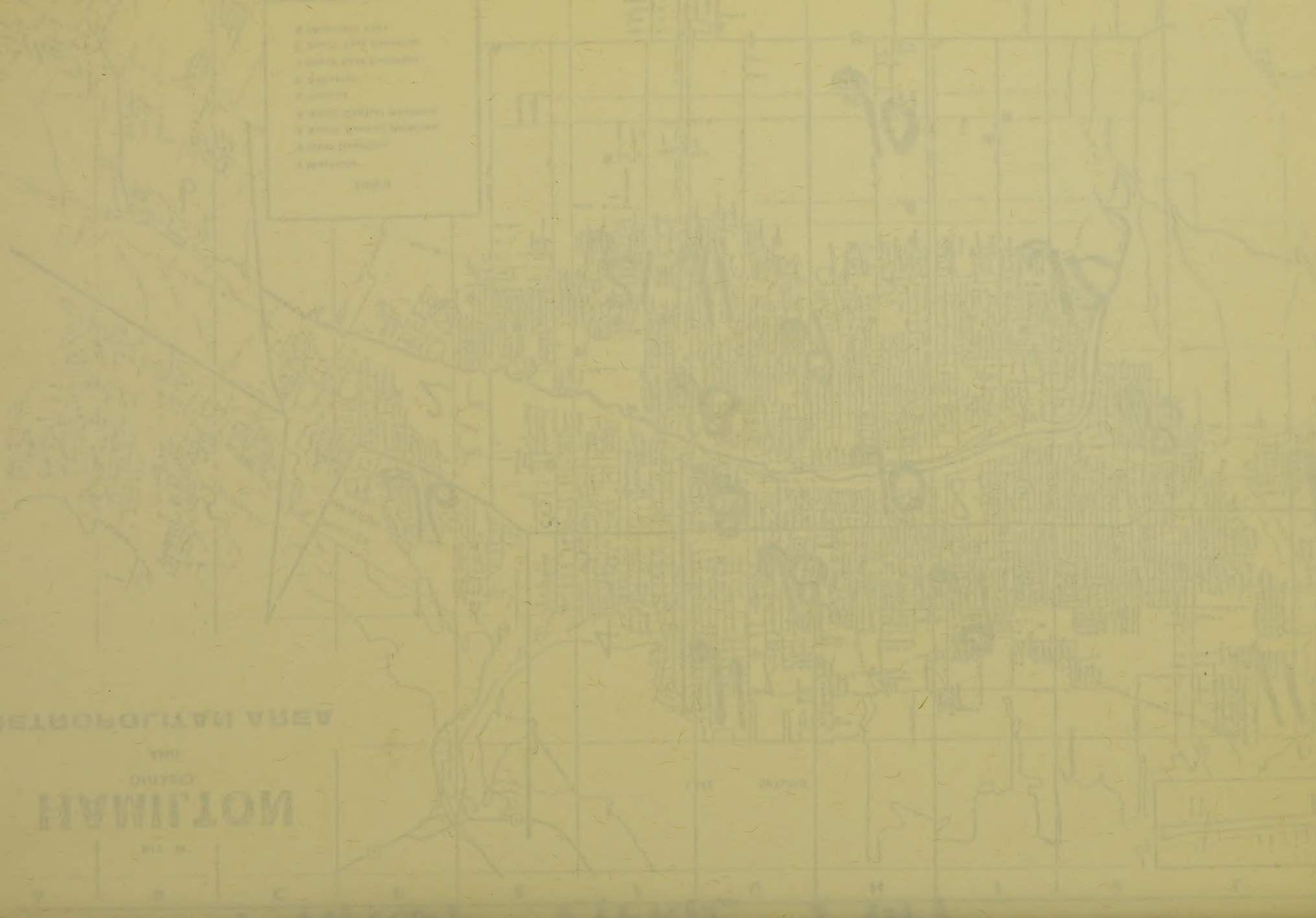


FIGURE 6-2

AVERAGE SO_2 CONCENTRATIONS IN ppb IN THE CITY OF HAMILTON FOR PERIOD JUNE - AUGUST 1980. EACH NUMBER REPRESENTS A SIX WEEK AVERAGE

FIGURE 6-2

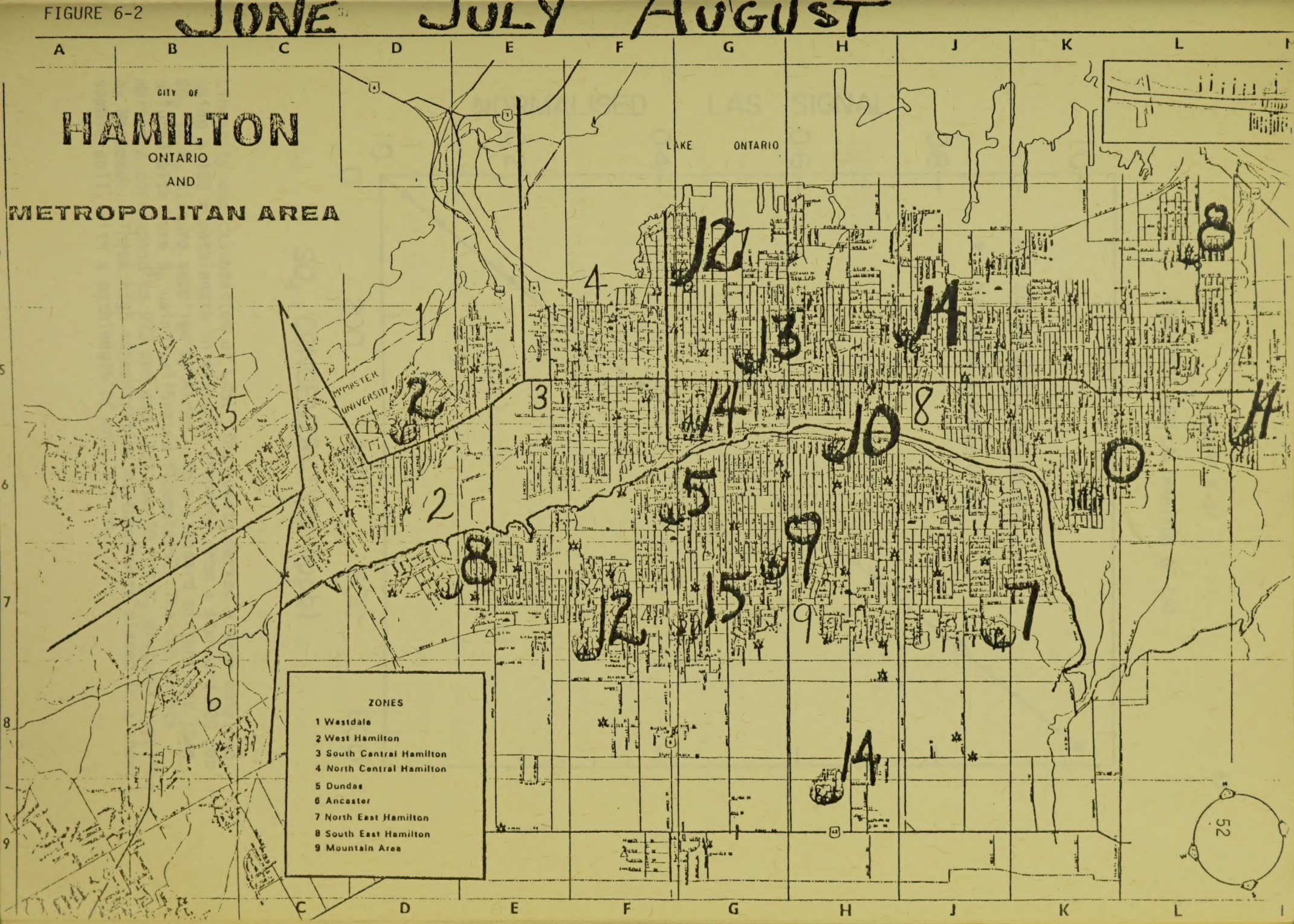
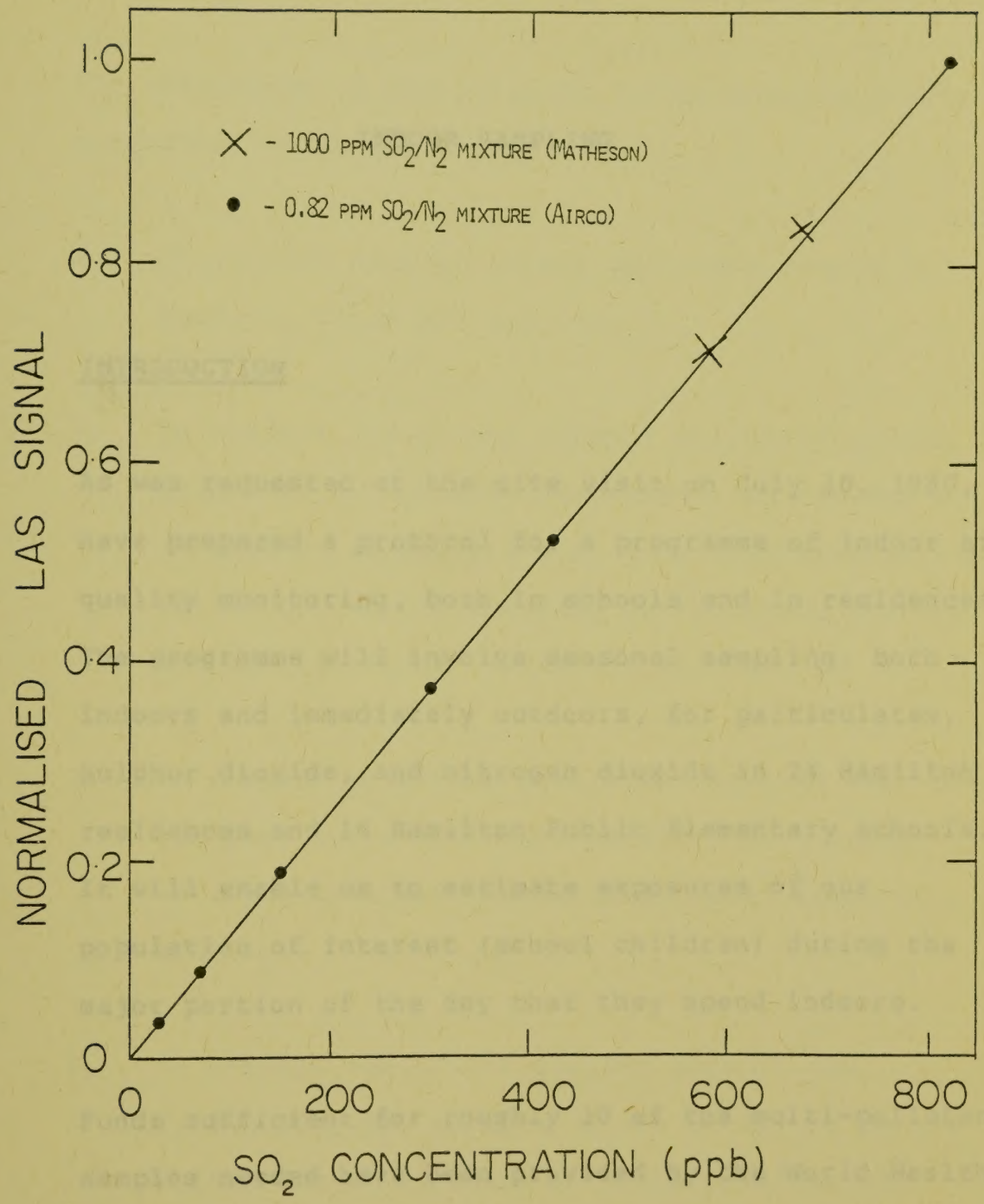

JUNE JULY AUGUST
CITY OF
HAMILTON
ONTARIO
AND
METROPOLITAN AREA
LAKE ONTARIO
MCMASTER UNIVERSITY
ZONES
1 Westdale
2 West Hamilton
3 South Central Hamilton
4 North Central Hamilton
5 Dundas
6 Ancaster
7 North East Hamilton
8 South East Hamilton
9 Mountain Area
52

FIGURE 6-3

LINEARITY AND CALIBRATION OF LAS



Linearity and calibration of LAS. The points marked • were obtained using a 160 m pathlength in mixtures prepared from a standard 820 ppb SO_2 in N_2 mixture supplied by Airco. This standard mixture was then diluted with pure N_2 using calibrated flowmeters. The two points marked X correspond to 973 ppm and 1123 ppm SO_2 in N_2 mixtures supplied by Matheson. These high concentration mixtures were placed in a short sample cell, with a pathlength of only 9.5 cm.

PART 7

INDOOR SAMPLING

7.1 INTRODUCTION

As was requested at the site visit on July 10, 1980, we have prepared a protocol for a programme of indoor air quality monitoring, both in schools and in residences. The programme will involve seasonal sampling, both indoors and immediately outdoors, for particulates, sulphur dioxide, and nitrogen dioxide in 24 Hamilton residences and 16 Hamilton Public Elementary schools. It will enable us to estimate exposures of our population of interest (school children) during the major portion of the day that they spend indoors.

Funds sufficient for roughly 10 of the multi-pollutant samples needed have been provided by the World Health Organization; considerable further equipment funding and all operational funding are to be provided by the Environmental Toxicology Division of the Environmental Health Directorate, Health and Welfare Canada.

7.2 OBJECTIVES

The objectives of the proposed indoor-outdoor sampling programme are as follows:

1. To provide data on indoor pollutant levels in Hamilton homes and schools.

2. To compare indoor and outdoor pollutant levels (measured by the same instrument) to determine the effects on exposure and on indoor-outdoor pollutant ratios of varying building construction factors, and varying indoor pollutant sources.

3. To compare pollutant levels as obtained with the proposed multi-pollutant sampler, with these obtained by other standard, accepted sampling methods.

4. To provide indoor air quality data to the epidemiological portion of the study, to permit estimation of exposure of the population of interest.

7.3 THE SAMPLER

The sampler we are proposing to use is our line-power operated modification of a multi-pollutant sampler constructed by the Gage Research Institute in Toronto (with whom we are collaborating on this WHO-encouraged project). These modifications will permit 24-hour unattended operation of the sampler. Suspended particulates are collected on a downward-facing Teflon filter; these will be analyzed gravimetrically on a Cahn microbalance at McMaster. SO_2 and NO_2 are collected by splitting the air stream and passing each half through a separate bubbler and impinger. Analysis will be carried out in our lab. SO_2 analysis will follow the method of West and Gaeke (1956) and EPA (1971). NO_2 analysis will follow the TGS-ANSA method (Levaggi, 1973).

As paired indoor and outdoor multi-pollutant samplers are planned, and as at least one of the absorbing solutions is thermally sensitive, temperature-controlled enclosures, with stands, are required for at least the outdoor samplers.

7.4 SAMPLING SITES

Over the next year, we propose to sample for SO_2, NO_2, and particulates on a seasonal basis in 16 of Hamilton's

public elementary schools, and in 24 Hamilton residences. A Residential Characteristics description form will be filled out for each prospective residential indoor/outdoor sampling site. A similar form, the Commerical/Institutional Building Characteristics description form, will be filled out for each prospective school site in Hamilton.

7.4.1 SCHOOLS NETWORK

Schools in Hamilton may be divided into two general types: older, multi-storey schools and newer one-storey schools. (Each of these types have other pertinent characteristics, such as ceiling height, internal traffic pattern, and window area. Data on a number of these variables will be collected for each school chosen). Unfortunately, schools in the lower city, particularly in the more heavily-polluted areas, are of the older type, while those in the upper city are generally of the newer type. In this respect, choice of subject schools is limited. An attempt will be made to find one pair of each type in each quadrant for sampling. (These quadrants will be set up, taking into account pollutant concentration patterns). Sampling at each school will be carried out using one sampler inside and one sampler outside the school. The indoor sampler will be located in a classroom on the windward side of

the building (relative to the prevailing winds). In older schools, the sampler will be placed in a classroom on the main floor of the building. The sampler will be located on an inside wall, where possible, with the inlet three to five feet from the floor.

The outdoor sampler at any school will be located according to the following preference list:

1. in a secure location away from the subject school building, at least 50 feet from any road, and away from trees; or

2. on the roof of the building in a reasonably secure location as close as possible vertically to the indoor sampler, avoiding chimneys and vents as possible; or

3. located inside the same classroom, with an inlet probe extending through a port in the wall or window frame.

7.4.2 RESIDENTIAL NETWORK

Four residences of differring types will be located and recruited for this network in each of six sectors of the city. The types will be based on the presence or

absence of smokers in the home, construction materials used, the fuel used for cooking, and the permeability of the building (airtight, normal, or permeable). Sectors will be set up taking into account pollutant concentration patterns.

The indoor sampler will be located in the living area, or central activity area (not the kitchen) on the main floor. The inlet probe will be located three to five feet from the floor. Sampler locations will avoid the immediate vicinities of fireplaces, hot-air vents and window-mounted air conditioners where possible.

The outdoor sampler will be located:

1. at least 50 feet from the road, in the backyard and away from trees; or

2. on an apartment balcony; or

3. inside the residence, with the inlet probe extending through a port in a window casing. Where possible, this window will be located in the same room as the indoor sampler, or on the windward side of the residence (relative to prevailing winds).

7.4.3 ONTARIO MINISTRY OF THE ENVIRONMENT (OMOE) BARTON AND SANFORD STATION

This site has been selected to provide field validation of the particulate sampling function of the multi-pollutant sampler. This will be achieved by means of comparison with standard particulate sampling instruments at the site: daily TSP, hourly CoH (both available from OMOE), dustfall, and PSD (using McMaster Andersen cascade impactors). We hope to install three of the multi-pollutant samplers at the site for this purpose.

7.5 SCHEDULING

A 21-month programme is proposed, from September 1980 to the end of May 1982. Figure 7-1 shows the proposed time table.

Using a modification of the multi-pollutant sampler developed by the Gage Research Institute, sampling for SO_2, NO_2, and particulates will be carried out on a 24-hour basis. This will ensure data comparability with standard ambient particulate networks. When possible, supplementary eight-hour or 16-hour sampling will be carried out to quantify activity-period levels of these pollutants, and to permit direct comparison with the

unmodified version of the sampler.

7.5.1 SCHOOLS NETWORK

Air quality sampling in the schools will concentrate on the activity periods in the school year. Sampling at each subject school in the quadrant will require two weeks, in order to encompass all five weekdays (Figure 7-2). This allows for sampling every second weekday, to avoid the necessity of weekend servicing (as no access is available on the weekends).

The rotation (two weeks times four schools in each quadrant) will take eight weeks in each season. Generally, this rotation will immediately begin again, usually on an eight-hour basis, though this may be affected by breakdowns or sub-studies that seem necessary. The summer months (June, July, and August for this study) represent a special case. Sampling with students present will be possible only in June. Accordingly, all samplers from four of the six residential network sectors will be dedicated to the schools network during the month of June, to obtain summer data for all schools.

7.5.2 RESIDENTIAL NETWORK

Air quality sampling in the residential network is also designed to provide seasonal coverage for each site. To obtain data from all seven days of the week for each site in each season, it is necessary to arrange a three week sampling cycle in each residence (Figure 7-3). The design of this cycle provides for several opportunities to run eight-hour samples, permitting direct comparison with pollutant ratios observed in Toronto by Gage Institute Personnel. This rotational scheme (three weeks times four residences per sector) would require 12 of the 13 weeks in a season. The extra week will allow for any rescheduling that must be done due to breakdowns or access problems. As mentioned above, all samplers in four of the six sectors will be dedicated to the schools network during the month of June; those in the other two sectors will continue undisturbed. During July and August, all schools network samplers will be used to augment the residential network samplers. This will permit completion of the residential summer sampling programme on schedule.

7.6 STANDARD AMBIENT AIR QUALITY NETWORKS

In addition to comprehensive air quality data available, we plan to obtain further data from our own particulate

and gaseous pollutant networks. It is our plan to run the ambient particulate sampler nearest to the operating indoor/outdoor sampling sites in synchronization with those sites. This plan may be modified in two situations: first, if it proves to be impractical from a manpower-scheduling point of view; second, if it would cause loss of an unacceptable number of regular-schedule samples for that ambient sampling site for the month. In any case, at least some synchronized total suspended particulate and particle size distribution data will be gathered for comparison purposes. SO_2 data from our monitoring network is available on a continuous basis; NO_2 data may also be available on a less regular basis from our deployed laser spectrometer instruments.

7.7 METEOROLOGICAL DATA

Meteorological data, including temperature, humidity, barometric pressure, wind velocity, and wind direction, are gathered by the Atmospheric Environment Service at Mount Hope. Additional sources of this data in the Hamilton area (such as the Royal Botanical Gardens and the OMOE) will also be utilized.

7.8 QUALITY CONTROL

7.8.1 INDOOR-OUTDOOR SAMPLER CALIBRATION

The samplers will be calibrated on a regular basis at McMaster University, using dynamic environmental chamber methods. Desired NO_2 and SO_2 concentrations will be obtained by dilution of pollutant gas from 100% gas cylinders with compressed air to near-ambient concentrations. Both gases will be continuously fed and exhausted through the chamber. Chamber concentrations will be verified by our Laser Absorption Spectrometer system, which has been calibrated against both prepared gas mixtures (calibrated previously and traceable to NBS standards), and against known optical constants of SO_2 and NO_2.

The multipollutant sampling probe will be placed within 10 cm. of the SO_2 and NO_2 analyzer sampling probes. The chemical analysis concentrations obtained by the sampler will be compared with the average of five-minute readings for SO_2 and NO_2, respectively, over a 24-hour time period. SO_2 and NO_2 flows will be recorded hourly.

For particulate collection calibration, a number of the samplers will be run in parallel at one location, and the filter loadings compared.

7.8.2 SAMPLE ANALYSIS

As monitoring gets underway, samples will be divided and analyzed twice, in order to verify laboratory procedure. Later on, this duplicate analysis will be limited to a portion of the samples collected, to effect on-going control of technique drift.

Figure 7-1

PROPOSED TIME TABLE

1980	September	Preparations begin: hiring staff ordering equipment and supplies arranging sites arranging for vehicles setting up lab etc.
	October	
	November	
	December	Sampling begins
1981	January	
	February	End of "winter" sampling season
	March	
		END OF FISCAL YEAR
1981	April	
	May	End of "spring" sampling season
	June	Schools system "summer" sampling
	July	Residential system "summer" sampling
	August	Residential system "summer" sampling
	September	"Fall" season sampling begins
	October	
	November	Full sampling program ends
	December	"Clean-up" sampling Lab analysis completed Field work ended Data analysis begins
1982	January	
	February	
	March	Report preparation begins
		END OF FISCAL YEAR
1982	April	
	May	REPORT PRESENTATION
		END OF FISCAL PERIOD

Figure 7-2

Sampling Schedule at Each School in a Given Season

	S	M	T	W	Th	F	S
Week 0						M	
Week 1		X	S	X	S	X	
Week 2		S	X	S	X	M	

Where: X = Samplers running

S = Service network (collect samples and reset samplers for next sample day)

M = Move to new site and set up equipment

Figure 7-3

Sampling Schedule at Each Residence in a Given Season

	S	M	T	W	Th	F	S
Week 0						M	
Week 1	X	S	X	S	X	S	X
Week 2	(S)	(S)A	(S)A	X	S	X	(S)
Week 3	(S)	X	S A	A	A	A M	

Where: X = Samplers running

S = Service network (collect exposed samples and reset samplers for next sample day)

M = Move to new site and set up equipment

A = Days that may be available for 8- or 16-hour sampling

(S)= This schedule allows for several alternate servicing days, to limit difficulties caused by access problems.

PART 8

PRELIMINARY ANALYSIS OF YEAR 1 DATA

8.0 INTRODUCTION

Preliminary analysis of the Year 1 data has proceeded on several fronts with different objectives, some of which may be summarized as follows:

1. Continuing quality control;

2. Enhancing the data base of subsequent years by first year experience;

3. Sensitivity testing of outcome variables; and

4. Looking for early trends and confounders.

This partial summary reflects the activities that one of us (L.D. Pengelly (LDP)) undertook during a sabbatical year at the Faculty of Medicine, University of Newcastle, N.S.W., Australia with Dr. S.R. Leeder. A major part of his time was spent in learning and

applying techniques of data analysis to the first year's data from this project.

8.1 CONTINUING QUALITY CONTROL AND EVALUATION

The basic methods of quality control have been described in earlier reports. This includes a first screening of the data for outliers, which was carried out again by LDP in Newcastle in a slightly different way, using the BMDP statistical package program P1D. A number of anomalies were discovered in the Year 1 file that had been sent to Australia, which were corrected in the file in a similar way. However, many subsequent runs were made on the file using many different combinations of the variables, manipulated by a variety of transformations. This process also identified a few further outliers which could only have been identified on the basis of their interaction, one with the other.

8.2 ENHANCING THE DATA BASE

As a result of the preliminary analysis, it became apparent that the provision of one or two small pieces of information which we had not thought to include originally (or did not include because the need was not forseen), could add a further significant dimension to the analysis. Examples of these include:

1. Expansion of the information on colds of the child.
2. Birthweight of the child.
3. Sex and relationships of the smokers in the house.
4. Expansion of the questions on home heating.
5. Development of a formal smoking questionnaire.

8.3 SENSITIVITY TESTING OF PULMONARY FUNCTION VARIABLES

8.3.1 ASYMPTOMATIC NORMAL VALUES

We decided to separate the children with Pulmonary Function Test (PFT) data into two groups on the basis of the respiratory morbidity (RM) questions of the questionnaire. A positive response to one or more of six questions relating to persistent cough, persistent wheezing, presence of asthma, or a cold occurring either at the time of testing or up to 1 month prior to the time of interview would put the child into the "symptomatic" class. No positive responses in any of these categories put the child in the "asymptomatic" class. Analyses were then carried out, using multiple linear correlation analysis, on the relationships of the pulmonary function variables to age, weight, height and sex of the child. Where the contribution of an independent variable was found to be not significant ($p > 0.05$), that variable was dropped and the analysis

re-run with the remaining variables. The results of this analysis are given in Tables 8-1 and 8-2. A preliminary comparison of these data with published data for children (where available) has been made (Table 8-3) and, in general, good agreement has been found. Most information from other studies centres on various indices of the FVC manoeuvre. The data from our study agrees well, especially with respect to volume and flows at the higher lung volumes. This will be examined more comprehensively in due course.

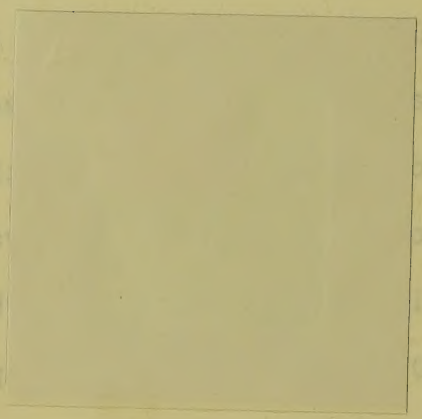
8.3.2 PFT SENSITIVITY TEST

After separating the children into two groups as described above, and assuming that a previous history of respiratory disease may reflect a deficit in pulmonary function, we tested the ability of the various indices of pulmonary function to discriminate between the two groups, on the basis of significance of the differences (if any) between the slopes and/or intercept of the multiple linear correlation. The results of this analysis are shown in Table 8-4, and show that two simple indices of the FVC manoeuvre (MET, and FEV1/FVC) show the greatest discriminatory power, whereas only 1 index of the other two manoeuvres we carry out (IDI) was discriminatory, but only just ($P = 0.044$). No index of "Closing Volume" (NWs) came even close.

The results of this analysis show that, particularly for those indices which are normalized for lung volume (MET, FEV1/FVC, V50/FVC, etc.), a number of indices of the FVC have shown the ability to discriminate between the two groups of children. Furthermore, this confirms our hypothesis that a measurable degree of pulmonary function deficit is associated with a history of respiratory morbidity. This analysis was presented at the Fall Meeting of the American Physiological Society (Toronto, 1980). (See abstract, Appendix 8-1).

8.4 TRENDS AND CONFOUNDERS

A description of a variety of demographic variables by quadrant was presented in the previous Report. Using some preliminary data on TSP, LDP in Newcastle separated the schools into areas with low, medium and high air pollution. The criteria were: low, 50-60 micrograms per cubic metre (ug/m^3); medium, 60-70 ug/m^3; high, over 70 ug/m^3. This was attempted as the original quadrant arrangement did not seem to yield sufficient air quality differences between "east" and "west". The results of this analysis on a few selected variables are given in Table 8-5. This table shows, as might be expected, that children living in areas of greater pollution tend to have less income in the home, tend less to have a father



in the home, and tend to have a higher exposure to cigarette smoke and a greater likelihood of exposure to fumes from gas cooking systems. These should only be regarded as trends, however, as a more detailed analysis with more complete air quality data is necessary. It does demonstrate, though, the difficulty which may be experienced in separating out the effects of factors which may all tend to produce similar effects on respiratory morbidity and/or pulmonary function.

An example of this may be found in Table 8-6 which shows the 12 RM questions grouped according to the presence or absence of smokers in the house. Four of these RM questions showed statistically significant differences between smoking and non-smoking households. As in the pilot study, the prevalence of colds going to the chest was much higher in smoking households than non-smoking households. This is also borne out by the observations of the pulmonary function testers, who observed more heavy colds, and particularly more heavy lower respiratory colds, in children from smoking than from non-smoking households, even though children from both groups seemed to get colds at about the same rate. Given that a greater proportion of smokers may be found in the "high" compared with the "low" pollution areas, it is clear that this question (the relationship of RM to smoking) should be subjected to at least one

additional level of analysis.

Table 8-1

MULTIPLE LINEAR REGRESSION COEFFICIENTS OF PULMONARY FUNCTION TESTS

FUNCTION	M REG COEFF	S.E.E.	INTERCEPT	REG'N FUNCTION	SLOPE	ST. REG COEFF	GROUP
FVC(b)	0.790	0.237	-2.218	WT	0.01390	0.235	1
				HT	0.02741	0.543	
				AGE	0.03069	0.082	
(s)	0.793	0.215	-2.415	WT	0.00870	0.157	2
				HT	0.02893	0.613	
				AGE	0.02877	0.080	
FEV1(b)	0.724	0.205	-1.234	WT	0.01081	0.238	1
				HT	0.01788	0.461	
				AGE	0.02803	0.097	
(s)	0.749	0.191	-1.851	WT	0.00439	0.097	2
				HT	0.02325	0.603	
				AGE	0.02949	0.100	
EV1/VC(b)	0.248	6.31	109.65	HT	-0.21155	-0.248	1
(s)	0.159	6.21	102.01	HT	-0.13415	-0.159	2
EF2575(b)	0.310	0.450	-0.648	HT	0.01921	0.310	1
(s)	0.415	0.451	-1.470	HT	0.02155	0.325	2
				AGE	0.06163	0.121	
MET(b)	0.231	0.148	-0.0278	HT	0.00461	0.231	1
(s)	0.132	0.140	0.1915	HT	0.00250	0.132	2
EF7585(b)	0.180	0.257	-0.0838	HT	0.00609	0.180	4
(s)	0.320	0.251	-0.7428	HT	0.01127	0.320	5
FF(b + s)	0.579	0.599	-3.516	HT	0.04295	0.444	3
				AGE	0.13318	0.182	
V50(b)	0.323	0.535	-0.6385	HT	0.01659	0.224	1
				AGE	0.07195	0.131	
(s)	0.432	0.532	-1.876	HT	0.02525	0.320	2
				AGE	0.08888	0.147	
V75(b)	0.193	0.325	-0.1262	HT	0.00837	0.193	1
(s)	0.313	0.320	-0.8531	HT	0.01410	0.313	2
VC(b)	0.795	0.234	-2.207	WT	0.01293	0.221	6
				HT	0.02750	0.557	
				AGE	0.03298	0.087	
(s)	0.786	0.219	-2.335	WT	0.00855	0.154	7
				HT	0.02859	0.671	
				AGE	0.02775	0.076	

Table 8-1 Cont'd

RV(b)	0.323	0.231	-0.7112	HT	0.01011	0.323	6
(♀)	0.307	0.198	-0.7628	WT	-0.00539	-0.165	7
				HT	0.01128	0.410	
FRC(b)	0.588	0.246	-2.142	WT	-0.00725	-0.157	6
				HT	0.02715	0.698	
(♀)	0.583	0.213	1.984	WT	-0.01065	-0.260	7
				HT	0.02596	0.751	
TLC(b)	0.767	0.319	-3.193	WT	0.00893	0.118	6
				HT	0.04286	0.673	
(♀)	0.753	0.293	-3.333	HT	0.04428	0.753	7
(b + ♀)	0.239	16.19	-3.193	WT	-0.2927	-0.114	8
				HT	0.6750	0.312	
(b + ♀)	0.171	0.260	2.332	WT	0.01058	0.260	8
				HT	-0.00696	-0.203	
VC (b = ♀)	0.237	0.171	-0.6084	WT	-0.00317	-0.119	9
				HT	0.00729	0.310	
VC(b + ♀)	0.101	0.081	-0.00075	WT	-0.00181	-0.147	9
				HT	0.00138	0.127	
TLC (b + ♀)	0.158	0.087	0.1793	WT	0.00311	0.232	9
				HT	0.00179	0.151	
TAN2 (b + ♀)	0.283	0.488	1.665	WT	-0.02185	-0.283	9

TABLE 8-2

COMPARISON OF SELECTED COHORT GROUPINGS AS TO MEAN AGE, HEIGHT AND WEIGHT

GROUP	CHARACTER	NUMBER	MEAN AGE	MEAN HEIGHT	MEAN WEIGHT
1	FVC BOYS	624	9.13	133.2	30.4
2	" GIRLS	595	9.09	131.7	29.5
3	" BOYS & GIRLS	1219	9.11	132.5	30.0
4	FEF7585 BOYS	536		133.7	
5	" GIRLS	515		132.1	
6	NWM BOYS	562	9.18	133.4	30.6
7	" GIRLS	534	9.13	132.0	29.7
8	" BOYS & GIRLS (6&7)	1096	9.15	132.7	30.1
9	NWS BOYS & GIRLS	934	9.26	133.4	30.6

TABLE 8-3

COMPARISON OF PREDICTED PULMONARY FUNCTION DATA

AGE = 9 HEIGHT = 132 CM WEIGHT = 30 KG

	PRESENT STUDY	STUDY 1	STUDY 2	STUDY 3	STUDY 4
FVC (boys)	2.09	1.79	1.84	2.03	1.97
(girls)	1.92	1.72	1.63	1.86	1.85
FEV (boys)	1.70	1.67	1.56	1.71	1.65
(girls)	1.61	1.63	1.36	1.62	1.59
MMEF (boys)	1.89	2.45	2.27	--	--
(girls)	1.93	2.50	2.38	--	--
PF (all)	3.35	(g)3.73	2.49	3.57	--
		(b)3.97	2.25	3.42	--
V50 (boys)	2.20	2.49	--	2.40	--
(girls)	2.26	3.04	--	2.46	--

LEGEND (Study Numbers)

1. Knudson et al Am. Rev. Resp. Dis. 113: 587-600, 1976
2. Dickman et al Am. Rev. Resp. Dis. 104: 680-687, 1971
3. Leeder et al Bull. Physiopath. Resp. 13: 249-260, 1977
4. Liang et al Aust. N.Z. J. Med. 5: 260-266, 1975

COMPARISON OF SELECTED INDICES OF PULMONARY FUNCTION FOR ABILITY TO DISCRIMINATE BETWEEN GROUP A AND GROUP S

FUNCTION	A GROUP	S GROUP	A MEAN	S MEAN	F RATIO	P	RANK
FVC	1219	1856	2.028	2.001	0.308	0.873	
FEV1	"	"	1.672	1.626	2.19	0.067	
FEV1/VC(%)	"	"	82.87	81.70	15.03	<0.00000	2
FEF2575	"	"	1.919	1.805	9.52	<0.00000	5
MET	"	"	0.5542	0.5873	18.56	<0.00000	1
FEF7585	1051	1551	0.7383	0.6959	6.55	0.00145	8
LSQT	1048	1546	0.3109	0.3354	6.04	0.00008	6
PF	1219	1856	3.387	3.239	4.58	0.00331	10
V50	"	"	2.243	2.100	10.35	<0.00000	4
V50/FVC(%)	"	"	112.57	106.60	10.72	<0.00000	3
V75	"	"	0.9961	0.9376	8.72	0.00017	7
V75/FVC(%)	"	"	50.15	47.86	5.41	0.00024	9
VC	1096	1667	2.056	2.032	0.653	0.625	
RV	"	"	0.6027	0.6005	0.374	0.772	
FRC	"	"	1.194	1.180	0.804	0.491	
TLC	"	"	2.685	2.632	0.810	0.488	
ADS	"	"	77.56	76.83	0.161	0.923	
IDI	"	"	1.727	1.760	2.71	0.044	11
CV	934	1327	0.2667	0.2627	0.372	0.773	
CV/VC	"	"	0.1275	0.1270	0.418	0.710	
CC/TLC	"	"	0.9958	1.002	0.820	0.441	

COMPARISON OF LOW, MEDIUM AND HIGH POLLUTION AREAS
FOR SELECTED FACTORS

GROUP	POLLUTION AREA LOW (50-60 ug/m^3)	MEDIUM (60-70 ug/m^3)	HIGH (>70 ug/m^3)
Number of Children	958	1684	706
% Cooking with Gas	7.1	12.7	33.0
% with Father at Home	80.6	78.6	75.8
Income			
Up to 10K	12.9	16.5	21.7
10K to 20K	36.8	39.4	41.6
Over 20K	44.2	38.9	28.7
REF + DK	6.1	5.2	8.0
Smoking			
None	38.5	37.2	24.3
<40	48.3	50.7	53.4
>40	13.2	12.1	22.3

NOTE: Percentages are of groups, not of total.

REF = Refused to answer.

DK = Do not know.

Table 8-6

RESPONSE TO RESPIRATORY MORBIDITY QUESTIONS BY SMOKING GROUPS

QUESTION (P=...)	RESPONSE	NONSMOKING NUMBER	NONSMOKING (%)	SMOKING NUMBER	SMOKING (%)	TOTAL NUMBER	TOTAL (%)
COFAM	YES	92	7.91	185	8.48	277	8.28
(0.6132)	NO	1071	92.09	1996	91.52	3067	91.72
COF3MOAM	YES	57	4.90	113	5.17	170	5.08
(0.7973)	NO	1106	95.10	2072	94.83	3178	94.92
COFDANIT	YES	126	10.83	284	13.00	410	12.25
(0.0771)	NO	1037	89.17	1900	87.00	2937	87.75
COF3MODN	YES	64	5.50	142	6.50	206	6.15
(0.2863)	NO	1099	94.50	2043	93.50	3142	93.85
WHEEZE	YES	269	23.15	589	26.97	858	25.64
(0.0179)	NO	893	76.85	1595	73.03	2488	74.36
WHZDN	YES	50	4.30	133	6.09	183	5.47
(0.0369)	NO	1113	95.70	2052	93.93	3165	94.53
ASTHMAT	YES	51	4.39	98	4.50	149	4.46
(0.9545)	NO	1110	95.61	2079	95.50	3189	95.54
CLDTOCHS	YES	372	32.18	923	42.38	1295	38.84
(0.0000)	NO	784	6782	1255	57.62	2039	61.16
CLDMON	YES	545	46.98	1011	46.33	1556	46.56
(0.7477)	NO	615	53.02	1171	53.67	1786	53.44
3WKCOFYR	YES	161	13.87	3335	15.38	496	14.85
(0.2626)	NO	1000	86.13	1843	84.62	2843	85.15
BRONPNYR	YES	82	7.06	191	8.75	273	8.16
(0.1018)	NO	1080	92.94	1992	91.25	3072	91.84
COLD	NONE	907	82.98	1618	79.47	2525	80.70
(0.0006)	PRESENT	43	3.93	75	3.68	118	3.77
	TWO	80	7.32	126	6.19	206	6.58
	THREE	17	1.56	56	2.75	73	2.33
	FOUR	46	4.21	160	7.86	206	6.58
	FIVE	0	0	1	0.05	1	0.03
SICKINDX	NONE	618	53.14	1174	53.73	1792	53.52
(0.4301)	CLDMON	447	38.44	789	36.11	1236	36.92
	+3WKCOFYR	63	5.42	134	6.13	197	5.88
	+COFDANIT	12	1.03	39	1.78	51	1.52
	+COFAM	11	0.95	24	1.10	35	1.05

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